THE INTERNATIONAL REVIEW OF WEATHER, CLIMATE AND HYDROLOGY TECHNOLOGIES AND SERVICES

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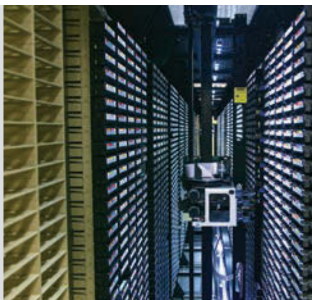
RIGHT TO THE POINT

David Grimes, WMO president, on his big vision and the forward thinking behind it



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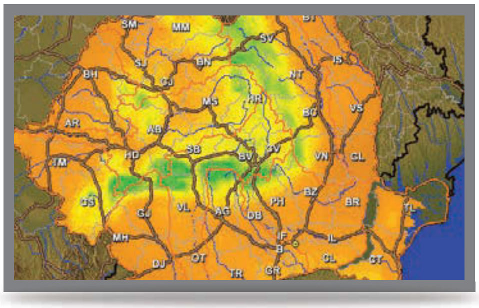

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CONTENTS

Cover image:
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144
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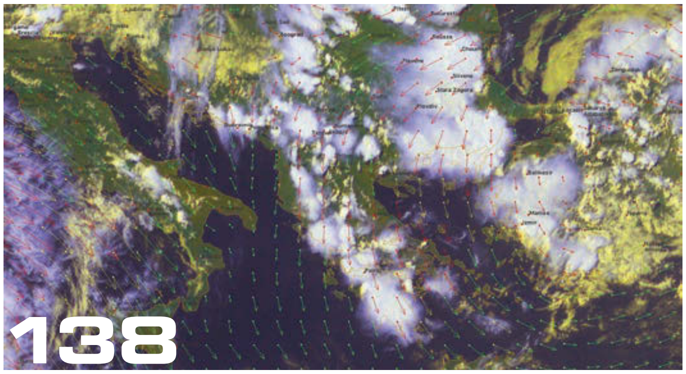
138

Welcome to *Meteorological Technology International,* the only review of weather, oceanic prediction, measurement and analysis technology

Another year, another Meteorological Technology World Expo. Except that isn't the case in 2013 because this, the only show dedicated to weather and climate-change measurement and prediction, is quite simply the biggest and best Meteorological Technology World Expo yet.

So what's new for this Expo, which takes place in Brussels, Belgium, from October 15-17? As well as filling a different hall at the Brussels exhibition center (we've moved to the larger surroundings of Hall 3), the show promises to showcase more exhibitors than ever before. Indeed, at the time of writing, we're expecting 160+ companies to show their very latest wares and services.

We've also doubled the size of the free-to-attend conference, with two presentation stages set to run concurrently. Headline speakers will cover subjects including radar innovation; developments in aviation and airport meteorology; agricultural weather and climate-measurement technologies and case studies; maritime weather-prediction innovation and examples; thunderstorm forecasting concepts; and ideas and innovation for improved information for offshore energy operators. You'll find a full program of events on page 66 of this publication.

Then there's the outside Technology Demonstration Area, which is located literally in front of the exhibition hall. It will be a unique opportunity to see some of the latest and most advanced prediction and measurement technologies operating firsthand.

A final additional attraction at Meteorological Technology World Expo 2013 – and perhaps the most significant – is the fact that it looks set to feature more brand-new product launches than ever. You can read about these never-seen-before technologies in the comprehensive preview from pages 50-65. And that same preview also highlights some of the numerous first-time Meteorological Technology World Expo exhibitors, the show attracting more and more leading and innovative industry suppliers. A trip to Brussels from October 15-17 really could be the best days you spend out of the office this year.

I look forward to welcoming you to Brussels in October 2013.

Graham Johnson
Show founder and managing director

Meteorological Technology World Expo will be even bigger in 2013

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by Christopher Hounsfield

WEATHER GURU

A man of huge influence, WMO president David Grimes discusses his vision

It is impossible to interact at any level of meteorology and not get involved with the World Meteorological Organization (WMO) at some point; its president says technology is on the verge of making a huge leap forward

The World Meteorological Organization (WMO) is multifaceted: global, economic, charitable, commercial, dealing with developed and developing nations… an instigator of programs, an initiator of strategic global plans. As an agency of the United Nations, it is the UN system's authoritative voice on the state and behavior of Earth's atmosphere, its interaction with the oceans, the climate it produces, and the resulting distribution of water resources.

Just this month (August), the WMO decided on an initiative to update the Cloud Atlas and produce it as a digital version – authoritative, comprehensive and useful for operational observation systems. The Cloud Atlas was developed as a standardized reference document and training tool for meteorologists, as well as for those working in aviation, at sea and in agriculture.

One of the WMO's subsidiaries, the Commission for Instruments and Methods of Observation (CIMO), has set up a task team of experts from all over the world to examine the feasibility of updating the Cloud Atlas to become a web-based tool.

The previous month, the organization hosted an intergovernmental meeting regarding an ambitious international drive to cushion the impact of climate variability through the provision of user-orientated climate services such as seasonal outlooks, drought and flood advisories. Already there is agreement on an operational roadmap for the Global Framework for Climate Services (GFCS).

Just from these two examples, we can see that the WMO has a huge impact across many industries and countries. And at the head of this global organization is the secretary-general of the WMO, Michel Jarraud. His role deals with matters related to program management, policy, advocacy, overall supervisory, legal and executive functions. But there is also someone who is actually chipping away at the industry coalface.

The WMO president

Ronald David Grimes is not only assistant deputy minister, Meteorological Service of Canada (MSC), Environment Canada; he is also president of the WMO.

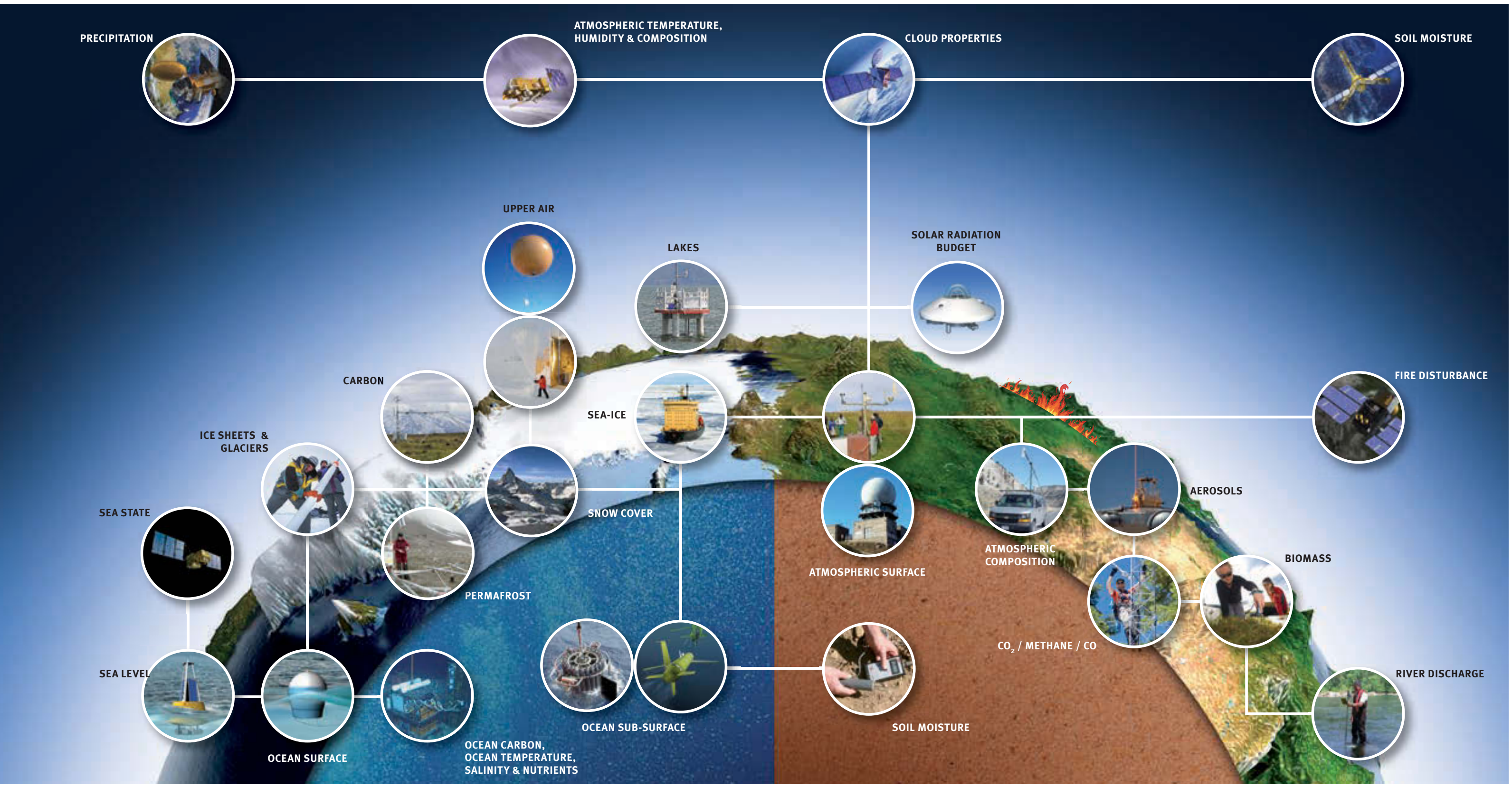
In a nutshell, by 'convention', the president of the WMO is accountable to the members of the WMO, playing a leadership and strategic role for the organization, while the secretary-general is tasked with leading the WMO Secretariat, based largely in Geneva, to facilitate collaboration. Drawing a comparative analysis to the private sector, the president serves as the chairman of the board and leads the strategic orientation of the organization, and the secretary-general serves in the capacity as the chief operating/executive officer. Significant work of the WMO is executed by the members themselves through participation of experts in established executive council committees, technical commissions and regional associations.

Grimes says, "We work very well together in ensuring that the WMO and its Secretariat is responsive to members' interests by facilitating the participation among National Meteorological and Hydrological Services (NMHSs) as well as other national entities through their Permanent Representatives.

"I have worked for more than 35 years in the MSC in various capacities, beginning as an operational meteorologist in Vancouver, British Columbia. I was appointed the assistant deputy minister in November 2006 and as the Permanent Representative for Canada with WMO at that time."

The WMO has initiated a strategic plan (see box on page 8) at a time when there seems to have been a resurgence of natural (weather-related) disasters and economic difficulties. How can a strategic plan be implemented? "I would turn this question around and say that to address the heightened risk of natural disasters and to build resilient communities, we need an instrument like a strategic and associated operating plan and budget to put emphasis on doing the activities that will provide the most benefit to enhance the performance of our members," says Grimes.

"Nevertheless, the sum of our collective resources, despite it being billions of dollars, is insufficient to do all things in all domains. Take, for example, ocean monitoring.



GCOS is a joint undertaking of the World Meteorological Organization (WMO) and other international bodies to provide comprehensive information on the total climate system

> "The sum of our collective resources, despite it being billions of dollars, is insufficient to do all things in all domains"

Oceans cover 70% of the planet's surface and our observing system must rely heavily on remote sensing from space as the cost of in situ monitoring at a high resolution is unaffordable. The strategic plan represents the desire of all members to put forward best efforts to maintain an array of observational networks, telecommunications, other related systems and processes, and the sharing of those data and derived products.

"The strategic plan allows us to identify the gaps and deficiencies in our systems, focus our limited resources on reducing those deficiencies, and avoid duplication of effort," Grimes explains.

The initiatives

There are many important initiatives in the WMO, as the mandate of the organization and its representative NMHSs is quite broad and varied. The WMO's 'convention' emphasizes the importance of standards and the exchange of data and information to support the provision of weather, climate and water services by its member states. The World Weather Watch (WWW) underpins these objectives and celebrates its 50th anniversary this year.

Grimes explains further, "This program, established at the 4th World Meteorological Congress in 1963, recognized the evolution of meteorological observations from space as vanguard nations launched satellites to explore the potential of watching Earth from space. Satellites offered the opportunity to visualize and track the movement of large weather systems and tropical cyclones from space.

"Around the same time saw the birth of computers, where various national meteorological services were beginning the modeling of weather systems with the aim of predicting their evolution. WWW established the means and communications pathways for sharing observational data from Earth and space in real time to support the forecast programs of national meteorological services around the world and the development of numerical weather prediction models. The quality of these models has improved significantly with the evolution of meteorological science and computers, and they are the backbone of the forecasting system worldwide."

This explanation takes us further on beyond the atmosphere. Yes, the WMO is hugely involved in space/weather/satellite programs, and yes, the organization is directly involved with space agencies around the world. "Cooperation is facilitated through a high-level meeting of satellite agencies that I personally chair," notes Grimes. "It considers the strategic dimensions, recognizing that planning timelines take up to 15 years from concept to launch, making this coordination essential to focus investment on. Details and technical issue cooperation are supported by the Coordination Group for Meteorological

Pre-launch tests of meteorological satellite TIROS (1960)

THE STRATEGIC PLAN

We know that the WMO has initiated a 2012-2015 strategic plan that is quite detailed. Can you, in layman's terms, outline what this is?

"WMO has articulated a strategic and operational plan for some years now; it was previously called a 'long-term' plan. The most recent plans were agreed by the WMO Congress in May 2011. The strategic plan is strongly aligned with the sustainable development goals currently being considered under the United Nations. WMO continues to be a key contributor to the safety of life and property worldwide through its members' prediction and early-warning systems; nations' abilities to sustain efficient economic outcomes in transportation, agriculture and water resources; and environmental outcomes through its Global Atmospheric Watch of its changing atmospheric constituents and particularly in support of climate adaptation through the Global Framework for Climate Services. The plan, which presents its mission, vision and strategic priorities, is prepared by integrating the priorities identified by members and WMO constituent bodies such as its six regional associations and eight technical commissions.

"In the plan, we outlined five areas of priority: the provision of climate services; the provision of meteorological services to aviation; the development of the Integrated Global Observing System and related WMO Information System; services to mitigate the risks of natural disasters; and capacity development with priority on the least developed countries. The purpose of these emphases is to ensure that adequate efforts and resources were brought to bear to advance these critical issues globally through investments in existing program activities."

Satellites, where matters such as future requirements are developed and the coordination of the positioning of geostationary satellites or timing polar orbiting satellites are discussed. For example, China, at the last WMO Executive Council, agreed to explore the procedures to adjust its plans in order to include a series of FY-3 early-warning orbit satellites to offset delays in the US missions.

"Space weather is another critical issue addressed by the space program. Concerns have been expressed about the effects of ionospheric disturbances on communication and navigation signal strength, particularly in the high latitude ionosphere (over the Arctic). The potential impacts of space weather on our technologically dependent world cannot be underestimated. These impacts include degraded signal quality that may interfere with commercial air traffic, and damage to essential satellite services including important Earth observation satellites."

Developing countries

The WMO also has developing countries very high on its agenda. So how is it working with the least developed countries and remote, but vulnerable, island locations, using data and programs?

"The WMO has established a number of specialized centers with expertise in, for example, telecommunications, typhoon warnings and drought, and for emergency response for the release of radionuclides," explains Grimes. "These centers provide products and services that serve many members on a regional basis. The development of these centers stems from a realization that not all NMHSs have the human or financial capacity to do the necessary research, modeling or data archiving to address these specialized areas. Furthermore, to have such attributes in all services would be very duplicative and costly – there are built-in efficiencies in conducting our business this way.

"Developing countries, least developed countries and small island developing states benefit from the transfer of technology and knowledge through this and other aggregations. Our Least Developed Countries program is taking further steps to support or augment programs in the least advantaged areas of the world. One of the key ingredients to advance our five priority areas is our Education and Training Program, which provides the core foundation and develops the skill-sets that are so important for NMHSs worldwide to be able to serve citizens well."

The vision

Grimes is actively involved and interested in a large cross-section of subjects, but has particularly strong views on the biggest problems regarding meteorological prediction, and how they could be solved.

"We need to improve our understanding of the Earth System, a complex interaction of physical and biogeochemical processes often investigated on a domain basis," Grimes states. "This calls for more coherent action and cooperation among many disciplines who speak in different context and use different terminology. For example, a biology perspective versus an atmospheric one. Nonetheless, we are all investigating similar things: how this small planet supports life; how its processes are being changed or disrupted; and what the human-induced causes of those changes are versus natural variations. From the life of bees to the occurrence of Category 5 hurricanes, these

The British Antarctic Survey Research Station conducts ozone studies, among other activities

can all affect humanity and eventually the behavior of our weather patterns and variability of the climate system.

"The second dimension of this issue is timescale. People, in my view, do not make the same discrimination between weather and climate timescales as the scientists do; that distinction is arbitrary at best. With the evolution of computational capacity and scientific advancements, we are fostering a seamless approach to prediction. A unified numerical weather and climate modeling platform permits improvements to be integrated at all timescales and goes further in validating the underlying processes that climate projections and predictions require. While we can validate weather prediction, it is more difficult for climate models.

"Looking into the crystal ball, I see the continuous improvements in all of the technology and science that supports weather forecasting, as well as the promise of better seasonal and inter-annual climate predictions at global and regional scales. There are many potential societal and economic benefits to be realized in having foresight of the changes in these timescales."

Poles apart

Another project that enthuses Grimes is the WMO's ongoing drive to better understand polar weather systems. Such work will be crucial in achieving more effective prediction systems for the globe, and Grimes acknowledges that while there has been significant investment over many decades in weather prediction at temperate tropical latitudes, the poles are not so well understood. However, this is set to change: "We are observing significant meteorological variability at both poles due to rapidly changing climate patterns," he says. "These are marked by sea ice-melt – a record minimum in 2012 in the Arctic, and destabilization of continental and Greenland ice sheets. We have launched the Global Integrated Polar Prediction System (GIPPS) building on renewed and timely scientific focus on the poles drawn from the International Polar Year [IPY – March 2007 to March 2009]. The World Weather Research Programme Polar Prediction Project will address the two shorter timescales, while the World Climate Research Programme Polar Climate Predictability Initiative will investigate the longer timescales. The two are seen as building blocks for the GIPPS.

"By addressing three timescales – from minutes to seasons, from seasons to decades, and centuries – we should better understand why the Arctic is changing rapidly while the Antarctic changes are uneven," Grimes continues. "More importantly, we will expand our knowledge and improve predictive skill on the effects of these changes on weather patterns and climate at the national, regional and global scales.

"From a weather and climate perspective, what starts in the poles does not stay in the poles – these changes have profound effects on weather and climate systems worldwide," he concludes. ∎

RISK ASSESSMENT

The WMO has initiated a disaster risk assessment using data and analysis with guidelines and a team of experts. Can you describe how this will work internationally and from a technical point of view?

"To introduce some context, the growing impact of disasters – both of the catastrophic and small-scale recurring variety – illustrates the imperative of a shared role for governments and the private sector in disaster risk reduction and to build resilient communities. The growing urbanization of Earth's population and, in particular, the growing number of megacities, calls for more integrated and coordinated actions, engaging the national meteorological and hydrological services, emergency measure organizations, vulnerable communities and local leadership, in disaster risk reduction and preparedness.

"The 4th Global Platform for Disaster Risk Reduction, hosted by the UN Office for Disaster Risk Reduction, took stock of progress in the implementation of the Hyogo Framework for Action (HFA) 2005-2015 and identified gaps that remain. In addition, it also allowed for initial multistakeholder consultations on the development of a successor framework to the HFA beyond 2015. It noted that, while results have been achieved, such as the reduction of mortality from weather-related disasters in particular, risk continues to increase due to the existing public and private investment policies and development practices."

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Exhibitor list updated 9 August 2013

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FROM THE PUBLISHER OF METEOROLOGICAL TECHNOLOGY INTERNATIONAL
RS THAN EVER,
S THAN EVER, MORE
PERS THAN EVER
SHOW YET!

by Christopher Hounsfield

VOICE OF THE PEOPLE

Brian Day, president of HMEI, reveals his top priorities

Working closely with the World Meteorological Organization, HMEI is the association for hydro-meteorological instruments and systems manufacturers of all sizes

Brian Day is the chairman of the Association of Hydro-Meteorological Equipment Industry (HMEI), as well as president/CEO of Campbell Scientific Canada. The association holds a general assembly, usually each year, which is organized to coincide with one of the major international industry equipment exhibitions, since it is a forum for commercial companies with their interests at heart. Also the association has, as one of its main activities, the objective of organizing and promoting meetings, conferences and seminars for the furtherance of meteorological and hydrological instruments and measurements, and related equipment issues.

Day presides over the annual HMEI general assembly and sessions of its council, and coordinates the activities of the association in the interim. He also presents the views of HMEI to the World Meteorological Organization (WMO) Congress and its executive council, and ensures appropriate HMEI members liaise with WMO expert teams.

What is the purpose of HMEI?
HMEI provides a unified voice for the international members of the hydro-meteorological instruments and systems industry. Our interests are in the standards and operations of meteorological, hydrological, climatological, and other environmental equipment and services. The association is also used as a means of communication and information sharing between developers, manufacturers and users within the industry worldwide.

Our goal is to contribute to worldwide standardization in meteorological and hydrological fields, and to promote the interests of our members with relation to guidelines and government policies.

What is the association's relationship with the WMO? How do the two organizations cooperate and integrate?
HMEI was granted 'consultative status' with WMO in June 2002. Consultative status accords us entitlement to be represented by a non-voting observer at sessions of the WMO Congress. We may also be invited by the secretary-general to sessions of regional associations and/or technical commissions in which our members may be interested. As an observer, HMEI is able to represent the interests of our member companies and speak on issues that concern our industry. We also work to promote the views of the HMEI membership, which now stands at approximately 120 companies, through participation in organizations such as the International Organization for Standardization and the International Telecommunications Union.

How does the global meteorological prediction industry benefit from an organization like HMEI?
As a whole, our industry is committed to ensuring that government agencies have the best information available through the use of our products. It is our feeling that with reliable data, these organizations will have the opportunity to better understand our environment and, as such, be better able to predict environmental changes.

With instances of severe natural disasters seemingly on the rise, the collection of quality data and forecasting has become integral to understanding the changes our world is seeing. As HMEI ensures that our industry's voice is present in discussions concerning designs, standards and operations of meteorological and hydrological equipment, and with our mutual goal being to attain the best possible measurements and information, the benefits to our member companies and to the global meteorological industry are myriad.

How does HMEI interact with its membership, and with the greater meteorological industry at large?
To benefit both our members and clients of the industry, the HMEI website hosts a 'profile' page for each of our member companies, where members can list details and images of their products, with links to their websites. In the past, WMO would work to develop a catalog of meteorological and hydrological products as a central reference, but given the pace at which technology is developed and released, the paper catalog was often outdated by the time it was published. HMEI has now taken over this role, and our website (www.hydrometeoindustry.org/) has become the central repository of product information where WMO members can quickly search for any company or instrument.

In 2012, HMEI began a project to redevelop our website to make it easier for our member companies to add and change their product offerings. This new site will be available for use by WMO members and others in January 2014.

In addition, a newsletter is published quarterly on the website reporting to the membership of meetings attended, of upcoming meetings and exhibitions, and other information of interest.

At an international level, HMEI collects and disseminates information and statistics relative to our own industry, and is able to share that information with our membership and other interested parties in the greater meteorological sector via the HMEI website.

How do you promote and coordinate your members' interests?

One of the major goals of HMEI is to establish and maintain strong international relations and facilitate good communication between developers, manufacturers and service providers. We also aim to provide a forum for discussion and resolution of matters of mutual concern for our members, and we do so by organizing meetings, conferences and seminars that focus on the advancement of technologies.

In what sort of projects is HMEI currently involved?

Recently, HMEI proposed a joint HMEI/WMO project in support of the WMO's Integrated Global Observing System (WIGOS).

WIGOS (pictured, right) is a new, comprehensive system of data sharing that would comprise information collected from existing global observing systems, the aim being to provide more integrated access to data required for effective delivery of services. While WIGOS is a key worldwide initiative of WMO, it will take dedicated cooperation between industry and WMO to ensure its success, and, as such, HMEI is proud to be involved in this joint project.

The proposed HMEI project consists of two phases. The first will focus on developing a practical, basic format for tender specifications for given hydro-meteorological and other environmental applications. Once completed, the new specifications could be used by National Meteorological and Hydrological Services organizations (NMHSs) as a baseline reference for any systems or products that these organizations are looking to purchase. The second phase of the project would facilitate specialized training for WIGOS implementation in WMO regions, with the goal to convene a series of consistent regional training programs for NMHSs. This would enable the least developed countries access to efficient acquisition and effective operation of weather, water and climate measurement equipment.

HMEI is working closely with the WMO on WIGOS

Are there any particular technical elements that HMEI places its focus on?

If anything, HMEI has interest in covering as many aspects of its industry as possible to ensure that the entirety of our membership is represented in discussions with the WMO.

HMEI has representation in almost 20 expert teams of WMO technical commissions. In close collaboration with WMO experts, HMEI representatives are addressing various aspects of hydro-meteorological observations, including data processing, technical advice, guidance, practices, and procedures for the improvement of national observing networks' operations. We actively encourage our membership to participate on these teams, as both our member companies and the WMO see great benefits from this collaboration.

You have mentioned that HMEI has interest in standardization – why?

One of the HMEI objectives is to promote and contribute to worldwide standardization in meteorological and hydrological fields. Currently, this is being accomplished through active participation with the relevant WMO expert teams. It is our view that a basic, universal standardization framework would promote consistent NMHSs procurement strategies, resulting in data of known quality and, in effect, better forecasting capabilities for the world as a whole.

What are the challenges of an organization such as HMEI working with the WMO?

In any close working relationship, such as the one that HMEI and the WMO enjoy, there will be issues or differences that crop up from time to time. The key is to remember that while both groups may approach a problem from differing viewpoints, we are linked by a common desire for the delivery of quality data. Coupled with honest communication, it is our passion and desire to work together that allows our organizations to resolve any differences that may arise.

How do you advance meteorological science and technology?

We feel that through our active participation in the work of WMO technical commissions and expert teams, and our promotion of international symposia, workshops and conferences, HMEI is able to foster our industry's growth not only as it pertains to our stakeholders, but also to the public at large.

Through the expansion of our organization, we are able to work in conjunction with many in our sector, as well as other sectors, in the interest of meteorological and hydrological sciences. This, along with our drive to champion the best possible quality of data, helps to advance HMEI's industry not only in the interest of our companies, but also as members of the global community. ∎

by Josh Wurman

TWIST IN THE TALE

Official warnings of tornado tracks are too unreliable and broad

In the light of the events surrounding the devastating El Reno tornado in May, expert Josh Wurman argues that tornado forecasts still have a long way to go – and can cause more casualties than the weather system itself

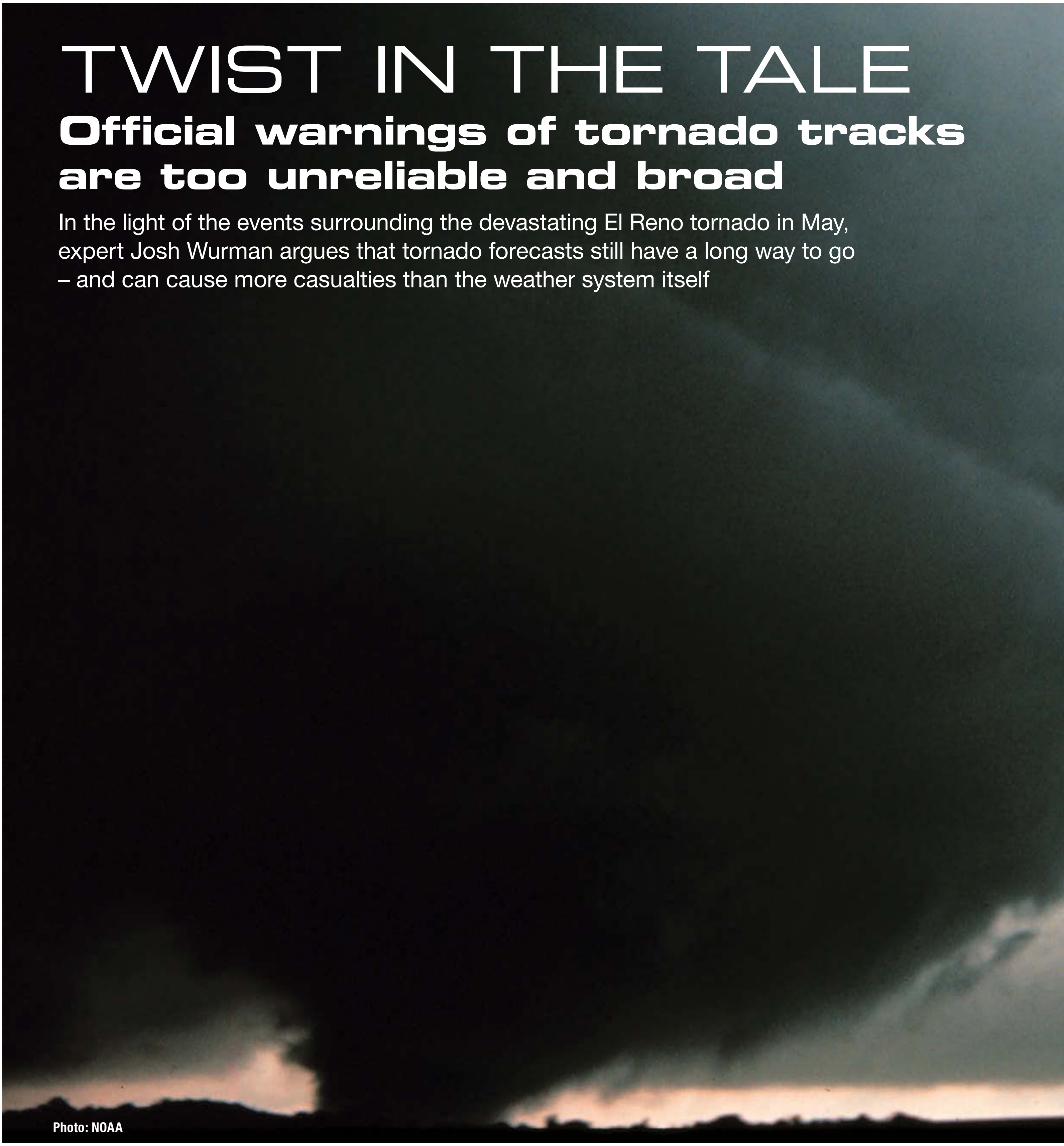


Photo: NOAA

Among researchers in the USA, forecasters and members of the public alike, the discussion surrounding tornado predictability often focuses on tornado warning lead time.

Lead time – the time between when a tornado warning is issued and a tornado is observed – averages 13 minutes. This represents a great improvement on decades ago. Some of this difference is due to a reduction in 'zero lead time' warnings, which used to occur frequently when the first warning of a tornado was issued when the tornado was observed visually.

The installation of a nationwide Doppler S-band radar network – the WSR-88D – has played a key role, enabling the detection of rotating supercell thunderstorms, the parents of violent tornadoes, and warnings to be issued based on these detections. However, tornado warnings are still in their infancy; the false alarm rate is very high, and precise predictions concerning intensity, track, width, structure and duration are beyond current skills.

Over-warning – the 75% false alarm

While most violent tornadoes are spawned by supercells, most supercells do not spawn tornadoes. Tornado warnings based on the detection of threatening-looking supercells have resulted in a 75% false alarm rate; 75% of warned storms never make tornadoes. There is concern that those hearing warnings do not seek immediate shelter, but rather seek to confirm the warning visually (for example, going outside to see if they can see a tornado approaching), or through friends (calling to see if someone else can see the tornado), checking on the internet, etc.

Scientists hope that intensive studies of tornadoes, such as the recent National Science Foundation (NSF) and National Oceanic and Atmospheric Administration (NOAA) sponsored VORTEX2, will improve our knowledge of the process of tornadogenesis, leading to both increased warning lead times and reduced false alarm rates.

Really, it's 99.9% false alarm

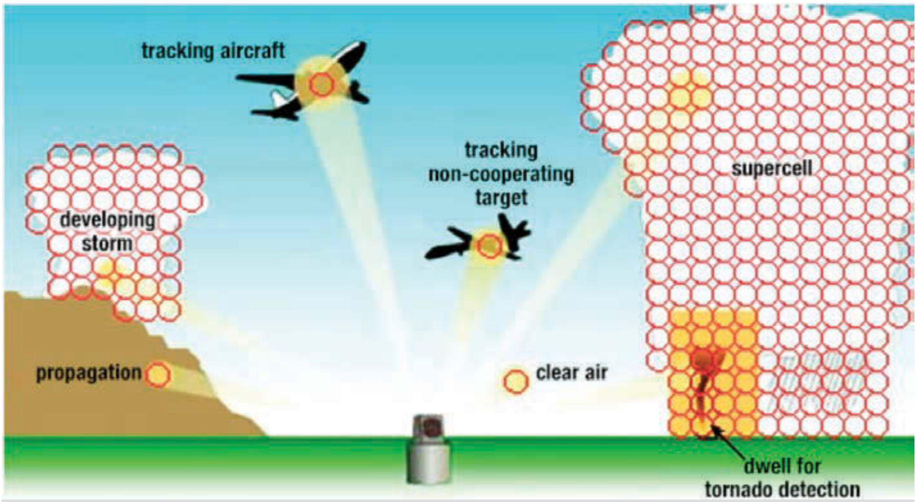
However, even if lead times and overall false alarm rates are improved, there remains a long path ahead for those working to improve tornado forecasts. The frequently quoted 75% false alarm rate is a huge underestimate of the true false alarm rate if the tornado-impacted area is compared with the tornado-warned area:
(area-impacted-by-tornado)/(area-under-tornado-warning) <<1 (usually <1%)

A typical storm-based tornado warning urges people living in an area approximately 1,000km^2 to seek cover, to go underground, or to get into strong rooms. The typical area impacted by a tornado, however, is maybe 3km^2 (a 5km path length x 0.6km impacted width = 3km^2). A recent DOW-radar-based climatology study has determined that the average diameter of maximum winds in tornadoes is 0.3km, with less damaging winds extending beyond, depending on the intensity of the tornado. Even a rare and very wide long-track tornado such as the recent one in El Reno, Oklahoma, May 31, 2013, impacted about 100km^2. So, typically <1% of a warned area is impacted even in the 25% of warnings when a tornado occurs, bringing the false alarm rate for tornado impacts up to about 99.9%.

Compare this with hurricane warnings. Hurricanes are also 'over-warned', but by much less of a margin. A hurricane warning might extend 300-500km along the coast. But typically, 10-20% of that area is impacted by significant winds and/or storm surge – a more than 10 times greater 'efficiency' compared with tornado warnings.

We can't forecast tornado futures

The precise track of a tornado cannot be forecast, so tornado warnings are issued for broad swaths 'downstream' of any ongoing tornado. Some notable examples of hard-to-predict tracks occurred recently during the spring of 2013. The powerful El Reno tornado was moving eastward across semi-rural terrain, then it turned northeastward toward Interstate I-40, then sharply eastward again. This changing track may have contributed to some of the injuries.



A phased array radar can simultaneously aide in aircraft navigation, detect severe weather and even scan for airborne terror threats

MULTIPLE-VORTICES, ANTI-CYCLONIC PARTNERS AND TRAGEDY

Complex multiple-vortex tornado structures increase hazards, but forecasters cannot predict if a tornado will have a simple single-vortex structure or something more complex. The El Reno tornado exhibited a pronounced multiple vortex structure.

Some of these multiple vortices moved in trochoidal paths about the center of the intense 2km-scale MVMC/tornado, posing an especially difficult-to-predict risk for those chasing, fleeing, or attempting to place instruments in the path of the tornado. Individual vortices contained winds of over 110m/sec and moved at ground-relative speeds up to 79m/sec, but at other times were nearly stationary.

Analysis of Rapid-Scan DOW data reveals that tornado researcher Tim Samaras and his crew were likely killed by a sub-vortex well inside the intense broader tornado/MVMC circulation. While the huge outer tornado/MVMC moved northeastward, an inner vortex formed just 500m south of the research team, moved north then northwestward, intensifying to contain winds of >81m/sec. The vortex became nearly stationary, centered just east of the research team, then moved rapidly eastward. The formation, intensification and looping prolate cycloidal path of this vortex would have been nearly impossible for that team to predict, particularly using only visual observations. Samaras's vehicle was transported initially southward, then eastward, about the nearly stationary subvortex, coming to rest ~500m east of its initial location.

Similar, but non-fatal, events such as this have impacted research teams before. In 2004, a DOW crew was able to elude an interior subvortex in the 2km diameter-of-maximum-winds MVMC/tornado in Geary, Oklahoma. The vortex was invisible due to blowing dust and rain, but was avoided through the use of real-time DOW-radar data. Winds of 87m/sec were measured at 12m AGL and the DOW suffered some damage, but the crew was uninjured. A smaller and less-armored vehicle than a DOW may have fared much worse. A media vehicle following a DOW was caught inside an MVMC/tornado, also exhibiting a 2km diameter-of-maximum-winds, in Seward County, Kansas, on May 8, 2007. Individual subvortices passed nearby, but, luckily, missed the vehicle, which still suffered significant damage but was not transported.

The development of a strong anticyclonic tornado to the south of the El Reno tornado – a rare, but not unprecedented event – made the El Reno storm additionally hazardous.

> "The El Reno tornado had the widest wind field ever measured, with a diameter of maximum winds measured near 2km wide"

An even more unusual and unforecastable tornado track was observed in a violent tornado near Bennington, Kansas, May 28, 2013. This tornado, with winds also over 110m/sec near the ground, persisted for well over an hour, remaining nearly stationary, looping over the same small area, turning back on its path. This unpredictability and looping track made it especially hazardous (those 'behind' the tornado were still at substantial risk), while simultaneously being initially extremely over-warned (since none of the areas 'downstream' of the nearly stationary looping tornado were ever impacted).

Tornado width

Wide tornadoes have a much greater potential to cause damage than thin tornadoes. The El Reno tornado had the widest wind field ever measured, with a diameter of maximum winds measured by DOW radar near 2km wide and potentially damaging winds extending for about 5km (DOW Doppler Velocity >50m/sec) or even 7km (DOW Doppler Velocity >30m/sec). This was an extremely strong multiple-vortex mesocyclone (MVMC), with winds in some vortices >110m/sec.

Tornadoes with 2km cores and ~5km swaths of damaging winds are rare (DOWs have documented such scales only three times before – in Mulhall and Geary, Oklahoma in 2002 and 2004; and near Seward, Kansas, in 2007) and nearly all tornadoes are much smaller. But tornado width, and thus the potential width of the damage swath, is cannot be forecasted.

Tornado intensity

No one can predict how strong a tornado will be – even a few minutes into the future. Only about 5% of tornadoes cause greater than EF2 damage. Since most tornadoes spend most of their lifecycles over rural areas, this is likely to be an underestimate of true tornado damage potential. DOW data has revealed that >50% of tornadoes are capable of causing EF2/EF3 or greater damage.

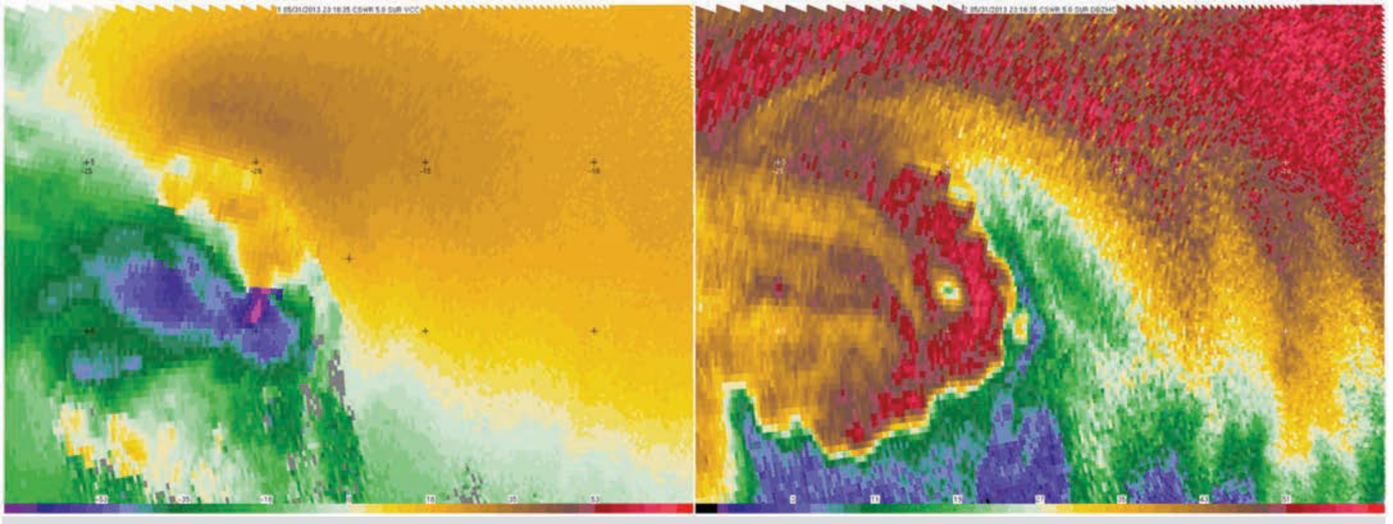
The actions one might take prudently in response to the approach of a tornado expected to be violent (say EF4/EF5) might be very different than one should take if a weak tornado (say EF0/EF1) were approaching. In the very rare event that a violent tornado was occurring (and you knew that the core region was heading toward you), leaving moderately strong shelter (say, an interior room of your house) to seek an underground shelter some distance away might be warranted. Similarly, the evacuations ordered prior to the landfall of a Category 5 hurricane are far more extensive, risky and disruptive than those advised prior to a Category 1 hurricane. This is for good reason: the hazard is much greater. Because we can't accurately forecast tornado intensity, however, responses to weak versus strong tornadoes can't be tuned to the actual risk.

Tornado demise

One of the potentially most consequential areas of ignorance concerning tornado evolution is our lack of ability to forecast tornado demise. Locations several tens of minutes downstream of every ongoing tornado are warned because we don't know how to predict when the tornado will die.

Most tornadoes are very short-lived; in most cases, tornadoes dissipate long before they traverse warned areas. The El Reno tornado dissipated well before it

The Rapid-Scan DOW can collect volumetric data in tornadoes, hurricanes, and other severe weather with updates every seven seconds



A zoomed-out view of the El Reno tornado and surrounding supercell thunderstorm. A very large intense wind field, with damaging winds extending for a width of up to 5km surrounded a 2km diameter most-intense region of the tornado

entered Oklahoma City, and no additional strong tornadoes formed. The city was spared. But, because the tornado's demise and the lack of subsequent tornadogenesis could not be forecasted, a Tornado Emergency (kind of a 'super' tornado warning) was issued for Oklahoma City.

Hundreds of thousands of people were warned in the strongest terms that a violent tornado could be heading their way, and to get underground or to strong shelters. Some television meteorologists even arguably suggested people (in the author's opinion, recklessly) to flee. The result of this extreme over-warning was panic. People were killed when they drove from their homes, subsequently abandoned their vehicles, and some drowned in water-filled ditches.

Highways, other roads and intersections were gridlocked with many thousands of vehicles. What would have happened if a large and/or violent tornado actually continued into Oklahoma City, or across the evacuation routes, destroying thousands of vehicles trapped in the ill-advised and panicky evacuation? The potential effects of violent tornadoes in urban areas have been studied, and they could be catastrophic, so Tornado Emergency warnings have a role. However, the impacts could be substantially exacerbated if people attempt, and fail, to flee and are caught in gridlock or in flooding ditches.

STUDIES OF TORNADO STRUCTURE AND EVOLUTION

Scientists are trying to learn more about the complex structure and evolution of tornadoes using multiple instruments such as mobile DOW radars, mobile mesonets, and Tornado Pods. The Rapid-Scan DOW, in particular, is able to measure the 3D structure of tornadoes every seven seconds. The 'regular' DOWs employ dual-polarization, two frequencies, and full time-series recording, which enables nearly instantaneous-duration (0.0002 seconds) intense velocities in very small sub-resolution-volume multiple-vortices to be measured.

Tornado Pods enable scientists to obtain multiple in-situ transects through tornadoes, measuring winds just 1-1.5m above the ground, far below where even close-up mobile radars can see. A recent study has even used data from an anemometer mounted on a homemade tank, the tornado intercept vehicle (TIV) combined with Rapid-Scan DOW data to map the 3D structure of a tornado. The National Severe Storms Laboratory is testing a phased array radar, which can provide much more frequent updates than the WSR-88D network. Despite all of this, as of today, scientists and forecasters still cannot predict the details of tornado evolution.

"Warnings are costly: business shuts down, lives are disrupted, and people sometimes die"

Better safe than sorry?

When faced with low-probability risks of extremely negative impacts, some amount of over-warning is appropriate. Balance must be achieved, however, between the frequency of warning, the consequences of not warning an actual event, and the extremely low probability of an event. 'Better safe than sorry' is not absolutely true. We wear seatbelts against the low probability of a vehicular accident, but we don't wear helmets against the infinitesimal chance of a meteor impact, and we don't wear parachutes on commercial airplanes. Warnings are costly: business shuts down, lives are disrupted, and people sometimes die during evacuations. Of the total 119 deaths related to Hurricane Rita (September 2005), 107 of them were due to the evacuation, and several deaths in the recent Oklahoma tornadoes occurred during evacuation.

Because there will always be uncertainty concerning tornadogenesis, tornado path, tornado width and structure, and tornado demise, it is inevitable that prudent warnings will be issued to more people than will actually experience direct severe tornado impacts. However, if we want to reduce the negative impact of the warnings themselves, and if we want to avoid the consequences of extreme over-warning, 'better' warnings in the future must also be fewer, smaller, and shorter in duration – basically more precise. Scientists and forecasters still have a long road to travel (sometimes literally), using the newest technologies, in their pursuit of a better understanding of tornado evolution. ∎

Josh Wurman and a technician deploy a rugged quickly deployable instrumented 'Pod' as Hurricane Ike approaches Galveston, Texas

Josh Wurman is a leading atmospheric scientist, inventor and storm chaser, noted for his world expertise in tornado, hurricane, and weather radar research, based in the USA

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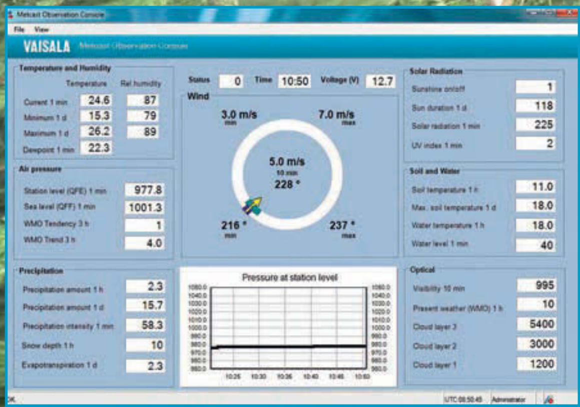

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VAISALA

by Jan Sondij and Siebren de Haan

AIRCRAFT AS A SENSOR

Using Mode-S EHS data to derive upper air wind and temperature information

Assimilation of Mode-S EHS derived observations in rapid update cycles of numerical weather prediction models will result in better nowcasts of wind information for the meteorological and air traffic management community

Upper air atmospheric wind and temperature information is crucial for numerical weather prediction (NWP) and nowcasting. The current observation systems employed to collect this information are radiosonde, wind profilers, Doppler radar, satellites and aircraft using the AMDAR program from the World Meteorological Organization (WMO). A novel method to measure wind and temperature is related to tracking and ranging by an enhanced surveillance (EHS) air traffic control (ATC) radar. This EHS radar interrogates all aircraft in sight in a selective mode (Mode-S), on which the aircraft replies with a message containing, for example, magnetic heading, airspeed and Mach number (figure 1). From this information wind and temperature can be extracted.

Origin of the initiative

The Royal Netherlands Meteorological Institute (KNMI) started research on employing Mode-S EHS data on the request of ATC the Netherlands (LVNL) in 2008. The objective was to develop and implement a system to provide nowcasting and forecasting of wind, temperature and air-density data in a 4D grid covering an area with a radius of about 250 nautical miles around Schiphol, Amsterdam, from sea level to FL450 (45,000ft).

The prime use of this service will be the trajectory prediction function for LVNL's 'arrivals' management. A second goal is the provision of meteorological data to airlines and other users in the air traffic management domain. LVNL provided KNMI with a 10-minute update of the Mode-S EHS data containing the downlink aircraft parameters (DAPs) of the BDS registers 4.0, 5.0 and 6.0 (Figure 1).

Derivation process and corrections

Since meteorological information is not directly measured in this way, preprocessing is necessary to obtain atmospheric information with adequate quality. Temperature is deduced from the Mach number and airspeed.

The wind vector is deduced from the difference between the ground track vector and the orientation and speed of the aircraft relative to the air, as shown in an idealized setting in Figure 2. The ground track is observed accurately but the aircraft orientation contains systematic errors, and preprocessing steps for heading and airspeed are essential (Figure 3). Since the magnetic heading is reported, a correction to true north is necessary. It is very likely that (slightly) outdated magnetic variance tables are used in aircraft and therefore an additional correction might be needed.

COLLECTING MODE-S EHS DATA WITH AN ADS-B RECEIVER

In cases where ATC is not able or willing to provide Mode-S EHS data, a good alternative is the installation of a local receiver. A trial performed by KNMI in 2012, using a commercial off-the-shelf ADS-B receiver, has shown that Mode-S EHS data can be received. The quality of the derived meteorological information is slightly worse than the meteorological data derived from the Mode-S EHS data received from ATC in the Netherlands (LVNL).

Derived wind speed and direction are within meteorological requirements. Air temperature derived from ADS-B EHS is not compliant with these requirements. The volume of the derived meteorological information is a small part, about 8%, of the Mode-S EHS data flow in use by LVNL. As at present the rapid update cycle of KNMI's HIRLAM NWP model uses about 2% of the available Mode-S EHS data and it is expected that the same relevant information for assimilation in HIRLAM can be received through a local ADS-B receiver. The cost of the local installation will be in the order of €1,000. For reasons of coverage, amount and quality of the data, as well as cost-efficiency, the reception of Mode-S EHS data directly from ATC is preferred by KNMI.


Delivering critical information
When devastating storms strike, advanced warning is critical to protect human life, property and commerce. NOAA's polar-orbiting satellites, the Ball Aerospace-built Suomi NPP and JPSS-1 satellites are the lifeline for accurate operational weather forecasts.
Suomi NPP
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Research also showed that aircraft have specific and time-dependent heading offsets. The true north heading is obtained by a correction of the reported magnetic heading for each aircraft and takes into account a latitude and longitude dependent correction based on a magnetic variance model as defined using Macmillan and Maus's *International Geomagnetic Reference Field*.

Two methods have been developed to determine the heading correction. The first takes into account the heading of the aircraft immediately after it has landed on the runway. When on the runway at a significant speed the heading of an aircraft and the runway should match. The limitation of this method is that the heading correction can only be applied for aircraft regularly landing at Schiphol. The second method uses external wind information from NWP and calculating backwards what the heading (and airspeed) of the aircraft should have been, assuming that the external wind factor is exact. The heading correction is calculated and used after 40 days with at least 15 days of observations from a specific aircraft. The advantage of this method is that observations are also derived from aircraft that cross the Amsterdam Flight Information Region at cruise level. A dynamic database has been constructed that determines the heading correction using both methods for every aircraft, every day.

Quality of the observations

The developed corrections were applied on a 4.5-year Mode-S EHS data set, and the resulting wind and temperature observations were compared with the ECMWF operational model data.

The Mode-S EHS derived wind direction has a standard deviation between 15° and 20°. The introduction of airspeed correction resulted in an improved wind observation with a reduction of 5% in wind speed error in the flight direction of the aircraft. By applying the airspeed correction, the wind speed bias is almost zero in this direction; the heading correction reduces bias and standard deviation in the transverse direction.

The improvement in the standard deviation of the wind observation in the north-south and east-west component is respectively 5% and 2%. Comparing co-located AMDAR and Mode-S EHS derived wind observations showed that the standard deviation of Mode-S EHS of 2m/sec is equal to AMDAR above 800hPa. Below 800hPa the standard deviation of AMDAR increases from 2m/sec to 2.5m/sec at the surface, while the Mode-S derived wind standard deviation is constant and equal to 2m/sec.

BDS Register	**Basic DAP Set** (if Track Angle Rate is available)	**Alternative DAP Set** (if Track Angle Rate is not available)
BDS 4,0	Selected Altitude	Selected Altitude
BDS 5,0	Roll Angle	Roll Angle
	Track Angle Rate	
	True Track Angle	True Track Angle
	Ground Speed	Ground Speed
		True Airspeed (provided if Track Angle Rate is not available)
BDS 6,0	Magnetic Heading	Magnetic Heading
	Indicated Airspeed (IAS)/Mach no. (Note: IAS and Mach no. are considered as 1 DAP (even if technically they are 2 separate ARINC labels). If the aircraft can provide both, it must do so.)	Indicated Airspeed (IAS)/Mach no. (Note: IAS and Mach no. are considered as 1 DAP (even if technically they are 2 separate ARINC labels). If the aircraft can provide both, it must do so.)
	Vertical Rate (Barometric rate of climb/descend or baro inertial)	Vertical Rate (Barometric rate of climb/descend or baro inertial)

Figure 1: Mode-S EHS downlink aircraft parameters (DAPs). Fixed wing aircraft that can provide the list of eight DAPs shown in this table are considered Mode-S EHS capable. Source: Eurocontrol

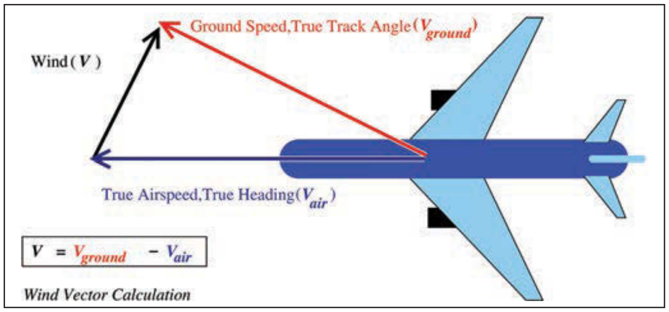


Figure 2: Schematic representation of wind derivation from aircraft flight information. The wind vector (black) is deduced from the difference between the ground track vector (red), the orientation (heading) and speed of the aircraft relative to the air (dark blue)

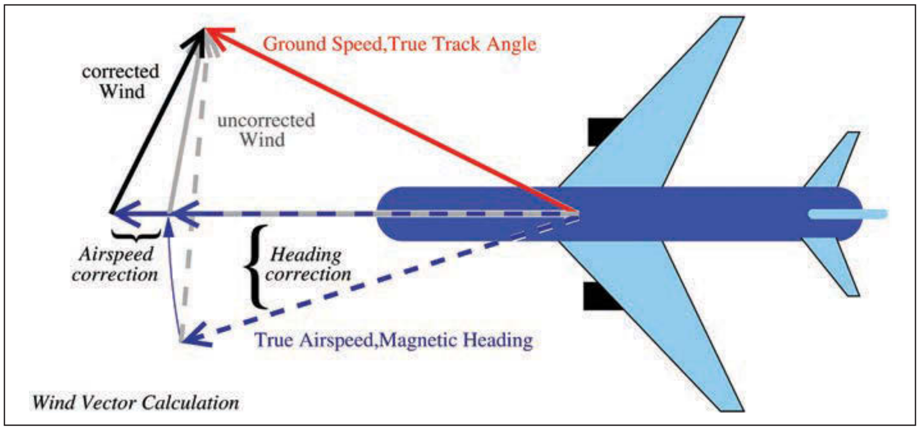


Figure 3: Schematic representation of heading and airspeed corrections used to derive high-quality wind estimate from aircraft flight information. The dashed white-blue vector (uncorrected vector) is constructed using aircraft downlink information of magnetic heading and true airspeed (see Figure 2)

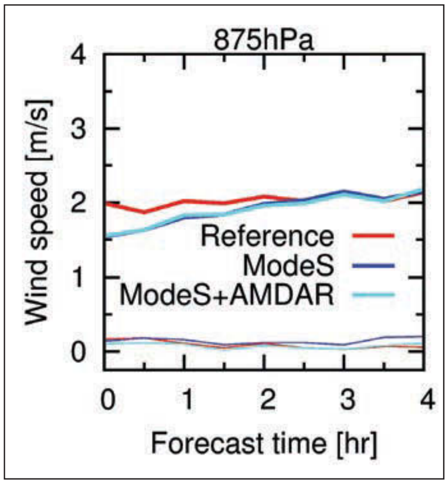


Figure 4: Impact of the assimilation of Mode-S EHS derived wind and temperature information in KNMI's Rapid Update Cycle Numerical Weather Prediction model (HIRLAM) on a 850hPa wind forecast. The mean difference (bottom lines) and the standard deviation of the mean differences (top lines) are shown. The impact of Mode-S EHS only information is visible up to 2.5 hours into the forecast; adding AMDAR extends it to nearly 4 hours

The corrected temperature observations showed an almost zero bias and an improvement of the temperature standard deviation by 50% above 750hPa. The temperature observations from AMDAR have a clear better standard deviation of 1K, although the quality of the Mode-S EHS derived and AMDAR temperature observations at 200hPa are almost identical. Overall the quality of the Mode-S EHS derived temperature is clearly less than the AMDAR temperature.

Assimilation into a numerical weather model

Upper air observations, especially wind observations, are important for short-range weather forecasting of extreme weather and for meeting new requirements in aviation meteorology. The impact of timely, high spatial and temporal resolution Mode-S EHS derived observations is assessed on the nowcasting time scale in the KNMI's HIRLAM NWP model by performing experiments with and without the new data.

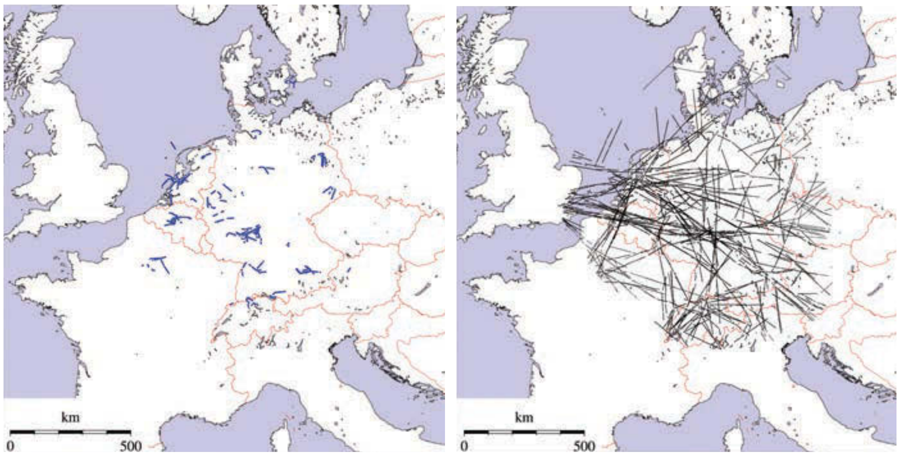
An hourly assimilation cycle is applied to exploit the high resolution (in space and time) of the new observations. Verification of the forecasts with independent Mode-S EHS aircraft observations shows clear analysis and short-range impact (figure 4). The HIRLAM background error and Mode-S EHS observation error statistics were not modified in this experiment to cope with the large observation densities. Research is ongoing to compute the background error correlation structure based on actual weather observation.

Benefits for ATM and the meteorological community

The future ATM system is developing toward performance based navigation as laid down in the ICAO Global Air Navigation Plan and the associated ICAO Aviation System Block Upgrades (ASBU). Important elements of this evolution, also described in the European ATM Master Plan, are the introduction of concepts such as 4D trajectory management, arrival managers (AMAN), departure managers (DMAN) and continuous descent operations (CDO). An important enabler for these concepts is the availability of accurate and wind nowcast and forecast information.

It is envisaged that aircraft could downlink accurate wind information directly as a source for deriving these accurate forecasts. Until this is implemented, deriving meteorological observations from, for example, Mode-S EHS data, and assimilating them into numerical weather models is an essential component in providing the ATM community with the accurate wind information it requires.

Using the aircraft as a sensor implies that observations are available only at locations where aircraft are operating. Furthermore, it is essential that ATC interrogates aircraft to provide the EHS BDS registers 4.0, 5.0 and 6.0, and that aircraft are capable to respond to this interrogation. For this reason there is, for example, no Mode-S EHS data available over the oceans. Finally, the meteorological community must be able to retrieve the EHS information either directly via ATC or by using a public ADS-B Mode-S EHS receiver.



Wind and temperature observations below FL100 (6.673) valid 2012/08/09 10:00-10:15 UTC

All wind and temperature observations (73.370) valid 2012/08/09 10:00-10:15 UTC

Figure 5: Current coverage of Mode-S EHS derived and quality controlled wind and temperature observations available at KNMI. The example shows 15 minutes of observations for a day in August 2012 over western Europe. Source: MUAC in ASTERIX Cat 48 format, processed by KNMI

Next steps and developments

Currently EHS designated airspace is notified by the Civil Aviation Authorities of Germany, the UK, France, Belgium and the Netherlands. Within this airspace Mode-S EHS data is available in all countries except for France, where data is expected to be available in 2014.

It is planned to expand the current geographical coverage of the observations (figure 5) by exploiting the Mode-S EHS data of France and the UK. The area can be further enlarged over the European area when more states implement Mode-S EHS.

A way to improve the quality of temperature observations is by consulting BDS register 4.4, which contains a direct temperature read out of the aircraft and is of similar quality to AMDAR. A dialog with ATC organizations is ongoing to explore opportunities in this regard.

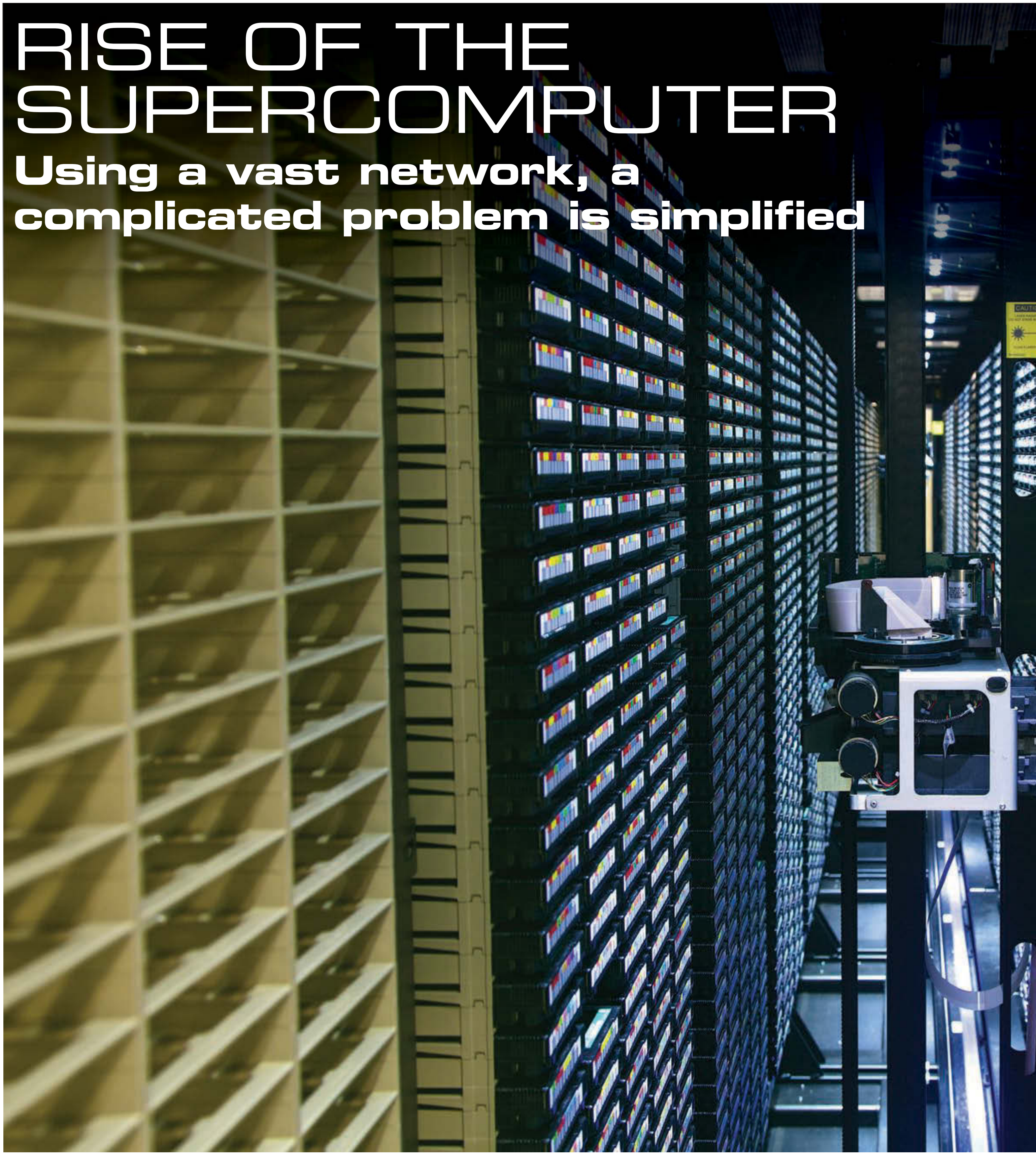
Research on the assimilation of Mode-S EHS derived wind and temperature observations in the non-hydrostatic weather model AROME/HARMONIE is part of the Single European Sky ATM Research (SESAR) program. More detailed information on the KNMI's Mode-S EHS program can be found at http://mode-s.knmi.nl. ∎

Jan Sondij, MBA, is a senior advisor aviation meteorology, and Dr Siebren de Haan is a senior scientist in meteorological observations and the scientific lead of the Mode-S EHS research. Both are with the Royal Netherlands Meteorological Institute (KNMI). *They would like to thank The Knowledge & Development Centre Mainport Schiphol (KDC) for partial funding and LVNL and MUAC for providing the Mode-S EHS data*

by Richard Millar

RISE OF THE SUPERCOMPUTER

Using a vast network, a complicated problem is simplified



Inside one of the UK met Office's data storing/sorting facilities. They can run ensemble forecasts, meaning they can run a model several times, each one from a slightly different starting point

The world's largest climate prediction experiment now celebrates its 10th anniversary with a massive global computing infrastructure that intends to change the way we look at climate prediction forever

It is an accepted argument that weather and climate change is a global problem that requires a global approach. ClimatePrediction.net is a climate science project that embodies this philosophy.

Based out of the University of Oxford, UK, ClimatePrediction.net distributes climate-modeling experiments to 40,000 home computers belonging to citizen scientist volunteers from across the world. Using the idle processor time on these computers, the simulations look at how temperatures, rainfall patterns and extreme weather events might alter under climate change. The results are then returned to the servers at the project base in Oxford and analyzed by the project's scientists.

The distributed computing approach used by the organization is a great example of employing the power of lots of computers to solve a large problem, enabling the project to achieve results that would take many times longer to achieve on an individual, even national scale, supercomputer. As such, ClimatePrediction.net represents a unique resource for climate scientists.

The system

ClimatePrediction.net uses the open-source BOINC software for volunteer computing to manage the distribution of work, from the central servers located in Oxford, to the volunteer's systems located around the world. This software distributes an experiment to the computer, monitors its progress and receives the results on completion of the computation. It then sends another experiment to ensure no idle computing time is wasted on the client's machine. The in-built graphics package enables participants to see the current state of the climate (temperatures, pressures, rainfall patterns, etc) as simulated by their computer.

The challenges of maintaining the computing infrastructure to operate the ClimatePrediction.net system can be considerable. The project's central servers in Oxford need to be constantly available to communicate with the computers of the project volunteers. With the inevitable resource limitations of an academic project, this has led to the use of innovative new technologies and methods to get around problems without busting the bank. In addition, a pipeline of simulations needs to be constantly maintained. This involves working closely with scientists from around the world who wish to use the project to conduct experiments.

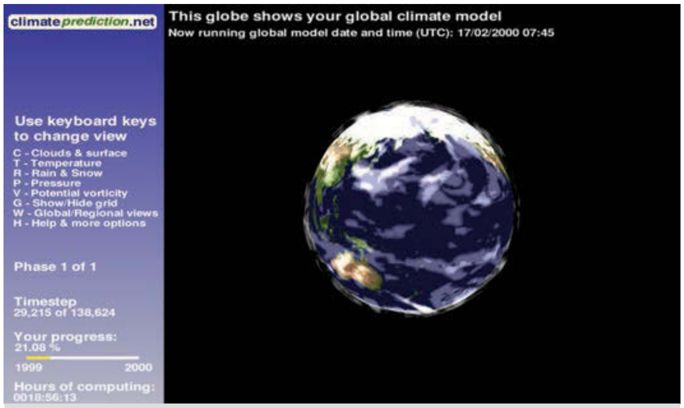
This global network of computers is a powerful resource, but what is it being used for? One of the particular advantages of using a distributed computing infrastructure is the availability of large amounts of parallel computational capacity. This enables the system to run very large numbers of models independently and enables the core group to examine the uncertainty in climate model projections.

Parameterization

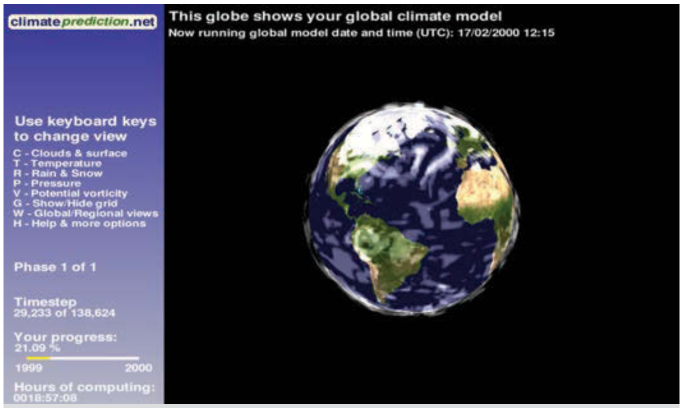
Climate models are inherently uncertain as they use a grid over Earth's oceans and atmosphere to solve the fundamental physics of the climate. The gaps between these grid points are limited by the computing power available today. This means that some phenomena that are important to the overall behavior of the climate exist on distance scales that are too small to be explicitly resolved by the grid. For example, clouds (which have a very important impact of the climate through their reflection of sunlight) typically exist on scales of tens and hundreds of meters, whereas climate models often have grid spacings of hundreds of kilometers. These processes hence have to be 'parameterized' in terms of the climate variables that the model explicitly resolves.

These parameterization schemes involve the fixing of numerical constants associated with the process being considered. Some of these parameters have very narrow ranges constrained by observations, but there are others that are poorly constrained to a narrow range of feasible values by either observations or more specialized models. With the many different parameters needed in climate models, these parameters can interact with each other in complex ways. Simultaneously varying these poorly constrained parameters across their feasible ranges can lead to equally physically plausible models that give quite different results for the same climate experiment.

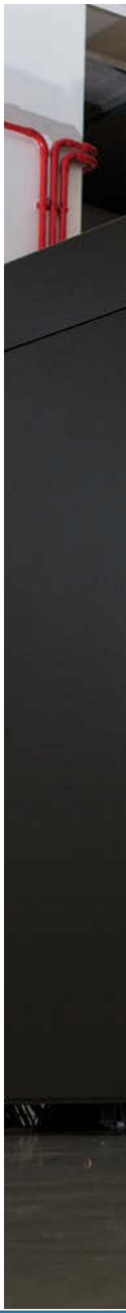
Science operates in the language of uncertainty. A result is only meaningful when its uncertainties are properly quantified. By exploring how the choice of these parameter combinations effects the results of the climate experiments, we are



Simulation on a volunteer's computer: global climate model, Pacific region



Simulation on a volunteer's computer: Atlantic region



moving beyond giving a single trajectory of a climate prediction into the future, devoid of any estimate of the uncertainty in the results, and into a world where the statement "On a doubling of atmospheric CO_2 concentrations, our model predicts a 2°C global average warming" is replaced by "On a doubling of atmospheric CO_2 concentrations, 80% of our models show a warming of 2°C or more."

Put the pieces together

The ClimatePrediction.net system is the ideal setup to investigate the effects of the many combinations of these parameters on the results of these experiments. On a supercomputer, each parameter combination would have been run sequentially. However, in the BOINC-based architecture, up to 40,000 different parameter combinations of the same climate experiment can be run simultaneously, making thorough exploration of the model's parametric uncertainty possible and practical.

Scientists on the ClimatePrediciton.net team in Oxford have been analyzing the results of experiments run on this distributed network of home computers to try to understand how the climate system works.

One of the first major results to come out of the ClimatePrediction.net project was published in the journal *Nature* in 2005 (Stainforth et al., 2005). This study showed the existence of models with extreme climate sensitivities (the average surface warming caused by doubling of carbon dioxide concentrations), when large ranges of possible model parameter combinations are considered. Another important result published in the *Nature Geoscience* journal (Rowlands et al., 2012) demonstrated a parametric uncertainty of 1.4-3°C global-average warming by 2050 in an ensemble of climate models that all recreate the observed climate of the second half of the 20th century. These results came out of an experiment run in collaboration with the BBC.

Day-to-day weather

ClimatePrediction.net also looks at the question of attributing the influence of human carbon dioxide emissions on the occurrence of extreme weather events. The weather@home project uses the Climateprediciton.net infrastructure to look at the effects climate change is having on the day-to-day weather. The project uses a configuration of the UK Met Office's atmospheric model for weather prediction, incorporating a high-resolution (small grid box spacing) regional model inside the global model. The regional model has a small enough grid spacing to explicitly resolve individual weather events such as storms and heat waves, while being run over climate timescales.

The atmosphere is an inherently chaotic system, meaning that small differences in the initial state of the atmosphere can lead to completely different predictions after a certain amount of time. This is the inherent reason why forecasting the weather more than a week into the future is a risky business. The weather@home project runs an ensemble of lots of slightly different initial conditions for the same climatic 'forcings' and looks at the statistics of how often particular weather extremes such as heat waves or large storms occur in the regional model.

Extreme weather

Running these ensembles via the ClimatePrediction.net infrastructure separately for pre-industrial climate and for the climate today enables comparisons to be made in the statistics of extreme weather events. It is therefore possible to make an estimate of how much more likely these events have been made by human-induced climate change.

GOING LARGE WITH SUPERCOMPUTER TECHNOLOGY

The UK Met Office's supercomputer is among the most powerful computers in the world. From the information it produces, the organization is able to provide more detailed and accurate weather forecasts.

Supercomputing capacity dictates the level of local detail that can be resolved by our numerical weather prediction models, and therefore our ability to accurately capture the environment, weather and climate. Computing power enables us to take in millions of weather observations from all over the world, which we use as a basis for running an atmospheric model containing more than a million lines of code.

The total system is capable of 1,200 trillion calculations per second, with a peak performance approaching one petaflop – equivalent to over 100,000 PCs and over 30 times more powerful than what it replaced. It has storage for 40 million gigabytes of data which is equivalent to 50 million cds or 750 million four-drawer filing cabinets.

The UK's Met Office supercomputer was upgraded in 2012 and now has a 1.5km mesh size model for the UK. This high resolution means that small-scale observations and localized severe weather can be identified enabling us to develop a more accurate picture of the weather than was ever possible before. It is also better at representing land surfaces such as hills and mountains.

The IBM supercomputer upgraded in 2012 for the UK Met Office can make 1,200 trillion calculations per second

Nearly all of the highest impact weather events in the UK are localized. Using the supercomputer, when heavy rain is forecast in potential flooding areas, the organizations can warn the relevant authorities earlier. It can also include more specific information about when and where it may happen, resulting in better prepared emergency services that are able to respond faster.

Previously, accurate flood predictions were viewed as near impossible, but using the 1.5km model, they can be issued on a much more localized level. The improved model was used to enhance the lead times of warnings of the flooding in Carlisle, UK, in January 2007, that was caused by heavy rain over the Lake District.

Further increasing supercomputing resource would lead to the realization of new and enhanced scientific services that currently lie dormant.

As part of the government's spending review earlier in 2013, the Treasury announced its intention to invest in a new high-performance computer at the Met Office. The announcement comes at a critical time in the UK's economic recovery and represents the potential for our science and services to help the UK prosper in the future by becoming more resilient, competitive and sustainable.

Jon Stanford, senior writer and editor for the UK's Met Office, is based in Devon, UK

INTERESTED?

ClimatePrediction.net is a 21st century solution for a 21st century problem. It offers a chance for participants to donate computing time to help understand both the climate on a global scale and also how climate change is affecting the weather on their doorsteps. Through ClimatePrediction.net people around the world are continuing to help understand how their world is changing. If you want to donate some of your spare computing time to understanding and predicting the climate, then please visit www.ClimatePrediction.net.

The weather@home team has used this method to investigate the impact of climate change on the 2010 Russian heat wave, the England and Wales floods in 2000, and even the wet UK summer of 2012. Currently, the high-resolution regional models exist for Europe, Western North America and Australasia regions. Collaborators at universities in these parts of the world are involved with the analysis of the output of weather@home relevant to their home region. These institutions include Oregon State University, University of Cape Town and the Carnegie Institution for Science at Stanford University. This coming year, several new regions are planned including a South Asia region and an African region with a set of new local collaborators.

Since its inception in 2010, the weather@home project has completed 172,831 model simulations, which is equivalent to 172,831 climate model years; 2,197 years of donated CPU time has made this possible. These simulations have been computed by 33,328 distinct hosts owned by 19,987 distinct users in 142 different countries. The first sets of results from the weather@home project have been published over the last couple of years. Otto et al. (Geophysical Research Letters, 2012) used weather@home data to investigate the causes of the Russian heat wave of summer 2010, which claimed 55,000 lives. The intensity of the heat wave was roughly comparable to what might be expected from natural occurrence, but the frequency that this scale of heat wave occurs was roughly three times the natural rate. The research also managed to reconcile two previous studies disagreeing about the human impact on the heat wave. The difference was found to lie in the different methodologies of the two previous studies (*Geophysical Research Letters, 2011*) focused on the intensity (special extent) of the heat wave; whereas Rahmstorf and Coumou (PNAS, 2011) formulated their study in terms of the frequency of such an event.

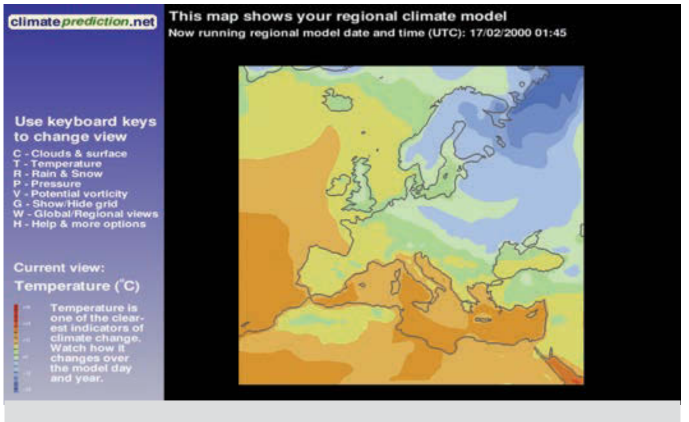
Shoreline at Hartwell Lake 2012. The Savannah River Basin has been in a prolonged drought since summer 2011 and has experienced significant rainfall deficit

Keeping going

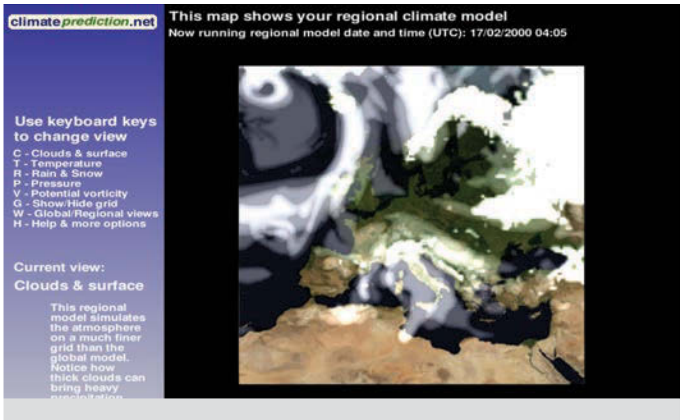
This autumn, ClimatePrediction.net marks its 10th anniversary and celebrates a decade of being the world's largest climate prediction experiment. The next few years should see the range of models available on ClimatePrediction.net increase as an updated version of the Met Office global climate model is adapted to use over the distributed computing infrastructure and new experiments are planned to investigate the impact of parameters associated with the land surface in climate models.

The weather@home project will also continue to grow, with further new regions and new collaborators becoming involved. ∎

Richard Millar of the Department of Physics, University of Oxford, is working on ClimatePrediction.net. He is studying the changes associated with increased carbon dioxide concentrations and geoengineering scenarios



Simulation on a volunteer's computer: European temperature range



Simulation on a volunteer's computer: European cloud cover

by Jon Verbeke

POWER TO THE STUDENTS

Development of a UAS for scientific monitoring

With global cooperation, students in Belgium have developed an unmanned aerial system to perform weather prediction along the North Sea coastline

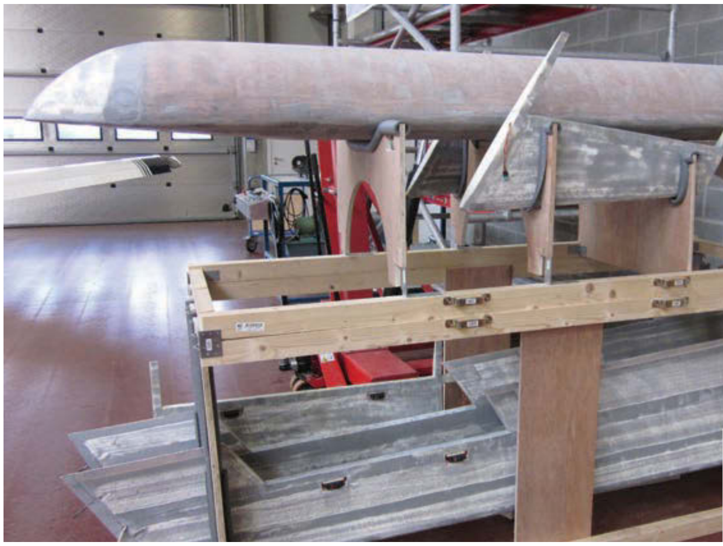
G55 FOREST FIRE MONITORING UAV

During forest fires, the Federal Aviation Police assist fire fighters on the ground with thermal camera views from helicopters. The long-lasting heavy bushfires at the 'Kalmthoutse heide' during May 2011 forced the helicopter pilots to the ground to rest. To solve this problem, Vives faculty was requested to develop a UAV. Two undergraduate students, together with the Federal Aviation Police, have designed and built the G55 fixed-wing UAV, which has a 2.5m wingspan. The G55 weighs 20kg, including a 2kg payload, and can easily be disassembled for transportation, fitting in a normal car. The equipment on board is flexible depending on the mission, such as a day/night camera for inspection, a thermal camera for forest fire monitoring, and radiation measuring equipment for nuclear radiation monitoring. In addition, the UAV is perfectly suited to perform flight tests with some of the Litus UAV's components, such as avionics. The hard work of the students was awarded with the VLRI prize for best undergraduate student thesis in 2011.

Over the past year, the UAV has been upgraded by an HEPH-Condorcet student with an electronic monitoring system to enable analysis of its flight behavior. The first test flight was successfully made in May 2013 (http://youtu.be/ZHPCStoOXvk).

In the future, the UAV will be optimized to enable the air vehicle to be deployed operationally.

The G55 before the first test flight



The disassembled Litus in its transportation box

An unmanned aerial system (UAS) consists of an unmanned aerial vehicle (UAV), a ground control station (GCS) and a command and control link (C&C) that uploads commands to the aircraft while downloading the aircraft's status and payload data.

As a basis for establishing a UAS expertise center, an extensive two-year research program was set up that would utilize the capabilities of students, lecturers and researchers to the fullest. This resulted in a UAS platform called Litus, which has been developed at the Aeronautical Engineering Department of Vives in Belgium located at the Flemish Aerospace Competence Centre (VLOC), with the help of educational, research and industrial partners. The UAS platform is aimed at performing scientific missions along the Belgian coastline of the North Sea.

Long-term weather predictions based on satellite data and experience show great accuracy. However, short-term weather predictions in the coastal area need much improvement because of the microclimate there. For Belgium, this is its coast on the North Sea. The sea influences the weather near the coast quite considerably. While inland the weather may be cloudy, at the beach it may be sunny and warm. More precise measurements are required in order to improve the forecast quality. The main problem in trying to make precise measurements is the lack of acquired data. Presently, measurements are taken in just a few places along the coast. The discrete nature of this data is the main obstacle to developing accurate weather forecasts.

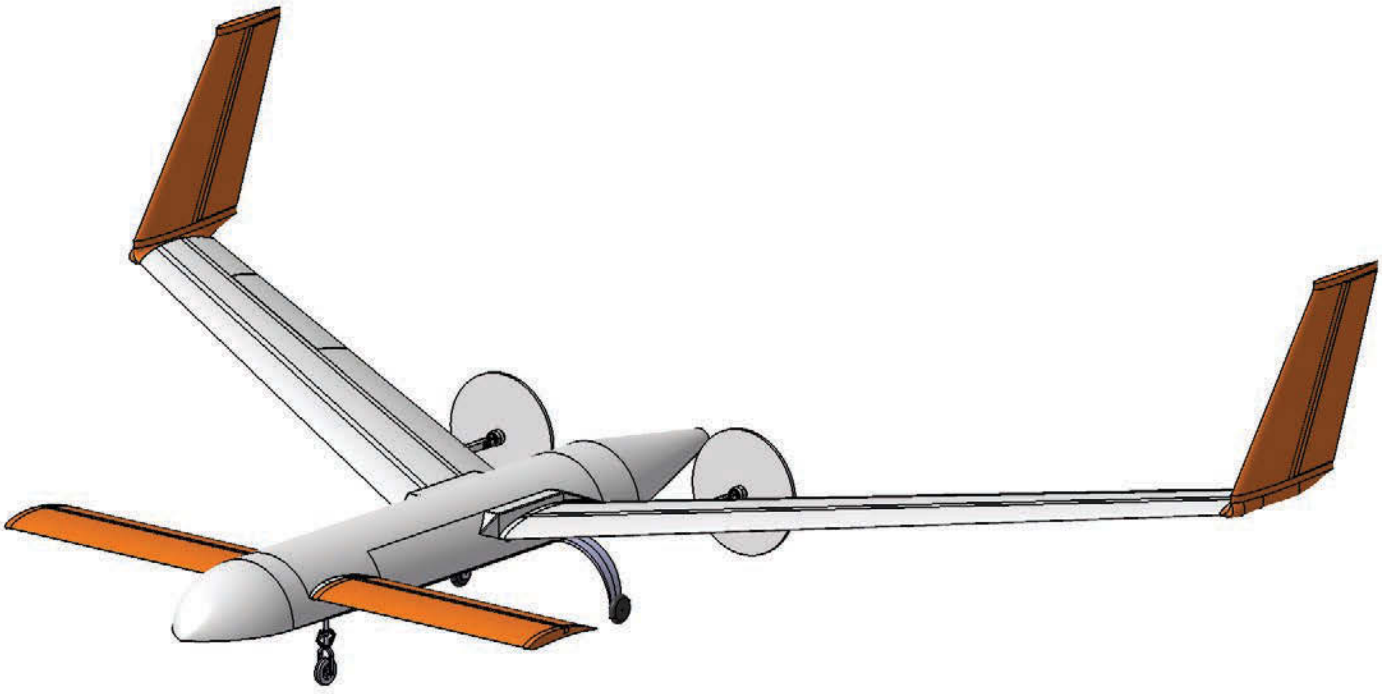
Economic effects

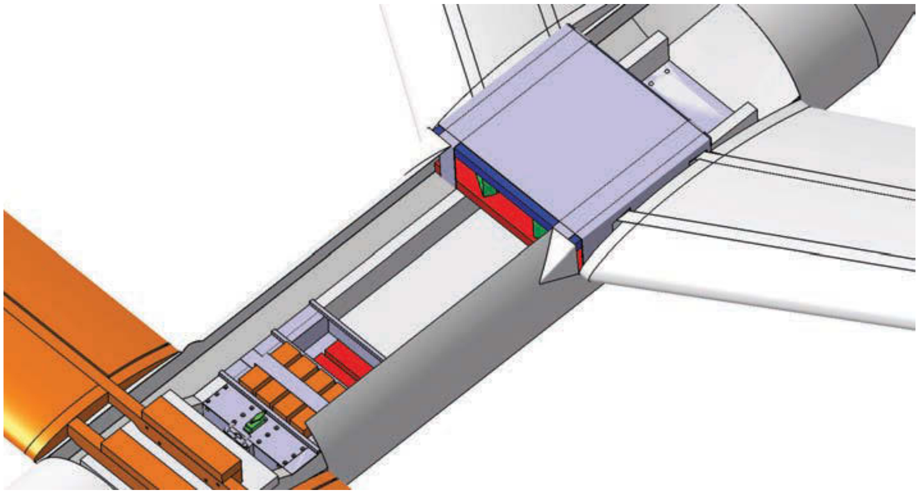
Why are these accurate forecasts necessary? The weather has a great influence on the economy of the Flemish coast. The most important players affected are tourism and the fishery industry. Currently, but only occasionally, a manned flight is made that measures the required data for weather forecasts, but it is very expensive and causes pollution. A much more suitable solution would be to deploy UAVs – more specifically, electric-powered UAVs. If the batteries of the UAV were charged by 'green power' when the vehicle is on the ground, the environmental impact of the UAV both in noise and emissions would be largely reduced.

The main performance requirement of the 65kg UAS is a range of 160km and a very flexible payload implementation up to 15kg. A propulsion system of two electrical brushless DC motors has been selected to minimize the environmental impact during operation by avoiding gas emissions and reducing noise. The UAS's name 'Litus' is derived from the Latin word for coast. Two years is a very short period in which to design an entire UAS platform from scratch, therefore a considerable amount of parallel research was performed by lecturers, researchers and students.

Students from all levels within Vives, KULeuven and foreign universities were employed to develop aspects required for the UAS. Professor Ivan Becuwe was the project manager. The design team comprised Rob De Roo as project leader and Jon Verbeke, author of this article.

The first step was to explore the current legislation. There is not yet any finalized Belgian UAS legislation, but some papers are circulating at a European level. Based on these papers and the project's constraints, the main (essential and optional) requirements were set. The next step was to find a suitable UAS platform configuration.





Above: 3D overview of the Litus

Left: The fuselage without covers, showing the payload bay

Below left: Testing the DC brushless motors and propellers in a Vives wind tunnel

Initially, three configurations were conceived, for which a conceptual design was performed, including 3D modeling in CATIA and aerodynamic analyses by graduate students during lab sessions. A lifting canard configuration was found to be the most energy efficient and was selected for further development.

Aircraft design

During the detailed design phase, the design of the aircraft was further refined and the systems developed. The main design of the aircraft was mostly done by the design team in CATIA based on the input of calculations and evaluated data from lecturers, specialists and students. Depending on students' workload, their availability and the difficulty of the task, data was taken from normal lessons, professional bachelor/master theses, internal/external internships, Erasmus projects and integrated courses.

After the fixation of airfoils and dimensions, a more detailed CFD analysis was made in combination with the evaluation of the UAS's weight and balance and its influence on stability. Because the aircraft is completely made of composites, one of the main concerns was the thermal behavior of the systems inside the aircraft. Several students investigated this. First, an electrical model was developed, after which

"The last things to be completed are the construction of the inner fuselage structure and the assembly of the fuselage-wing connection"

The Litus fuselage under construction showing the honycomb material as part of the skin

VIVES UAS COMPETENCE CENTER

The Catholic College University of Brugge-Ostende (KHBO), renamed Vives from September 1, 2013, and The Catholic College University of Zuid-West-Vlaanderen (Katho), saw the potential of UASs almost a decade ago.

Since 2004, several Bachelor theses have been completed and in 2010, Vives made the decision to thoroughly expand the UAS knowledge to enable the department to play a vital role in the Belgian civil UAS society and transfer the acquired knowledge to its students.

UASs are an interesting subject in education because they are a new type of aeronautical research with their own challenges (legislation, systems and advanced materials). The UAS industry for civil applications is expanding rapidly. In addition, the education of today's students is the basis for new technological evolutions in the future.

The basis of the start-up of the UAS competence center is, but is not limited to, the Litus research program. Parallel to the Litus research program, several other developments took place, such as the G55 fixed-wing UAV for forest fire monitoring, a gyrocopter UAV and PhD research to develop a harvest-estimation UAS for orchards. In short, the center's focus is on the development of all types of UAV for all sorts of missions.

The department has also participated in the Belgian UAS association BeUAS and the legislation workgroup that is writing the Belgian UAS legislation and has been working with the federal government in selecting a suitable commercial rotary UAV for disaster monitoring. A wide and profound base was laid by involving as many students as possible – each with their own background, interest and educational level. Over the past three years, more than 30 students, both national and international, have been involved with UAS research and development within Vives and the UAS competence center is considered a success. In the future, the focus will be on further expansion towards the industry and starting new projects in association with other academia and companies.

thermal properties were added. These were validated in system tests. The combination of both resulted in the accurate simulation of the energy management and the optimization of systems for different flight situations – for example, motor setting, outside temperature and flight path.

The brushless DC motors for propulsion were selected based on basic performance calculations found in literature, yet the actual thrust a specific propeller-motor combination could deliver was unknown. Accurate performance data is essential to calculate the take-off runway length, range and endurance, so an engine test bench was designed and built (see figure opposite, bottom left). The test data found that a motor-propeller combination was the most efficient. The production of the composite structure (wings, tail, canards and fuselage) was mainly done by the design team.

The electrical system was designed and built by the project leader and an Erasmus student. The composite main landing gear was developed and manufactured in-house by Vives Polymer Engineering students. The Litus can easily be disassembled and placed in a transportation box that fits into a van. The Belgian Civil Aviation Authority (BCAA) requires a technical construction file, an operational manual and a safety manual to approve test flights. By using the design principles of general aviation during the development, these documents are currently close to approval by the BCAA. Since no actual legislation exists, a safety-oriented approach was taken when design choices were not regulated by existing legislation. For instance, the electrical systems for propulsion, flight control and payload have been separated as much as possible to ensure that failure of one does not affect the others.

Ongoing research

In order to expand the knowledge of UASs beyond the Litus program, several other projects were performed. Vives students designed and built the G55 fixed-wing UAV, which can carry a thermal camera for forest fire monitoring in cooperation with the Belgian Federal Police.

However, Vives' capabilities are not constrained to fixed-wing aircraft. Slow (and stable) platforms such as a UAV airship and a UAV autogyro were developed and will undergo further test flights in 2013. Several other UAS-related subjects, both at a bachelor and master level, have been researched. In addition, one KULeuven PhD researcher is even designing, building and test flying a rotorcraft UAS platform for inspection of orchards and vineyards.

As of August 2013, most parts of the Litus aircraft are finished. The last things to be completed are the construction of the inner fuselage structure and the assembly of the manufactured fuselage-wing connection. Although the official project ended in December 2012, the design team has managed to ensure a follow-up project starting in September 2013 for one year to finish the UAV.

The UAV will be equipped with a suitable autopilot for enhanced capabilities and increased safety. Construction of the Litus should be finished by February 2014, after which ground tests will take place. The first test flights are planned for next year, June 2014. ∎

Jon Verbeke is a PhD candidate with Katholieke Hogeschool Brugge-Oostende (KHBO) in Belgium by Mohan K Das

SUB-CONTINENTAL SQUALL

3DVAR data assimilation Doppler radar data for nowcasting of tornadic violent squalls

The simulated results of squall storms in the Bangladesh region have provided a basis by which to study their microphysical and dynamic characteristics, without observations

During the pre-monsoon season (March-May) a lot of thunderstorms occur over north eastern India, Bangladesh, Nepal and Bhutan. They are locally known as 'Kal Baisakhi' or 'Nor'westers' as they usually propagate from a northwestern around to a southeastern direction. Nor'westers develop from a variety of mesoscale convective structures as they mature to mesoscale (200-1,000km) systems. These systems develop mainly due to the merging of cold dry northwesterly winds aloft and southerly low-level warm moist winds from the Bay of Bengal.

Squalls are defined as a sudden onset of strong winds with speeds increasing to at least 16kts (29km/h) and being sustained at 22kts (40km/h) or more for at least one minute. Several episodes of squalls occurred between May 1 and May 31, 2011. Widespread outbreaks of intense squalls occurred on May 11, 19, 21 and 23, 2011, affecting all the four countries in the region – India, Bangladesh, Nepal and Bhutan.

The three-dimensional variational assimilation (3DVAR) is designed to be flexible enough to be used for a variety of research studies in addition to its operational use. In this study, Doppler weather radar (DWR) observations (radial winds and reflectivity) from Bangladesh Meteorological Department (BMD) are used to study the four episodes of squalls mentioned earlier in order to update the initial and boundary conditions (IC/BC) through 3DVAR technique within the weather research forecasting (WRF) modeling system. It indicates that NWP models are very important for obtaining guidelines for the prediction of local severe storms.

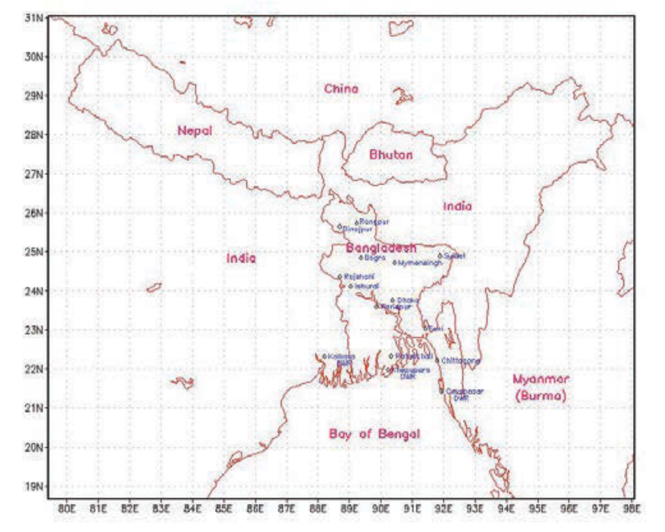


Fig. 1: Reflectivity (dBZ) observed by Doppler weather radar at Agartala on May 11, 2011

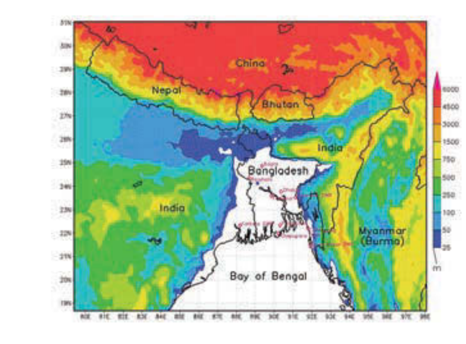
DWR Agartala recorded the vertical extent of the system of about 11km and the RADAR reflectivity of 52dBZ (Figure 1) on May 11, 2011 at 06:01 UTC.

Numerical model

The WRF model has been used over the study domain (Figure 2). The model is run at 9km resolution with 27 vertical levels by using six-hourly NCEP-FNL Data (1°x1°) as IC/BC. GTS and non-GTS data (AWS), Khepupara and Cox's Bazar DWR derived radial wind and reflectivity data are used in the experiments. Realized weather phenomena over Bangladesh and surrounding selected events of May 2011 are shown in Table 1 (overleaf). In Chittagong there are two meteorological observatories – the main meteorological observatory (MMO) and pilot balloon observatory (PBO).

DWR derived reflectivity and radial wind analysis

Bow type echoes of reflectivity are seen at 05:03 UTC of May 11, 2011, at 00:59 UTC on May 19, 2011, and at 12:03 UTC on May 21, 2011 – see Figure 3(a), 3(b) and 3(c). In Figure 3(d), the bow-type echo is not seen, but a comma-shaped echo is seen. These are the indications of squall lines and severe thunderstorms.



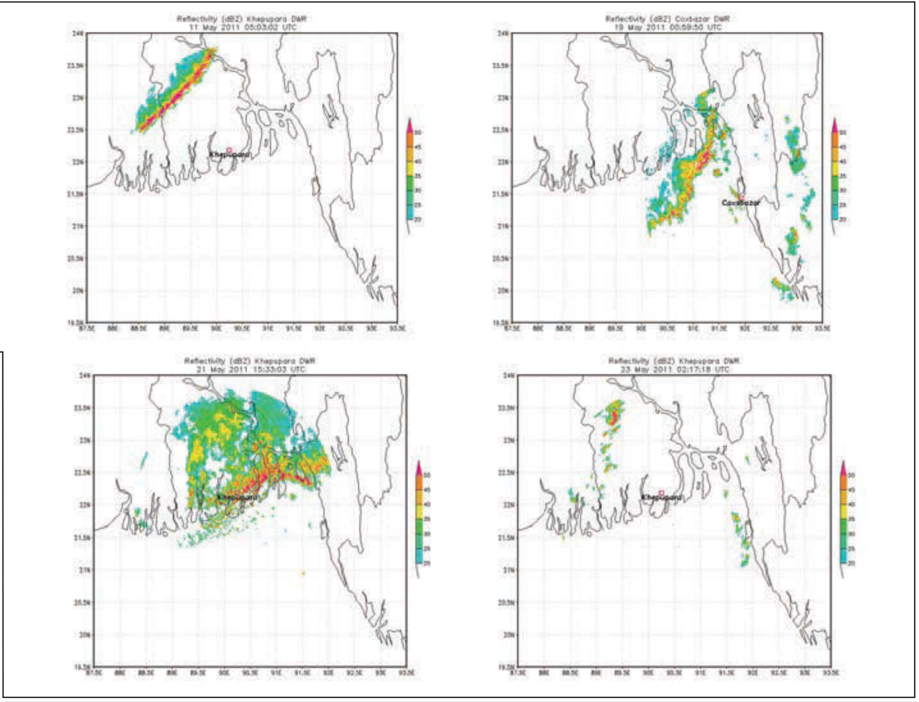


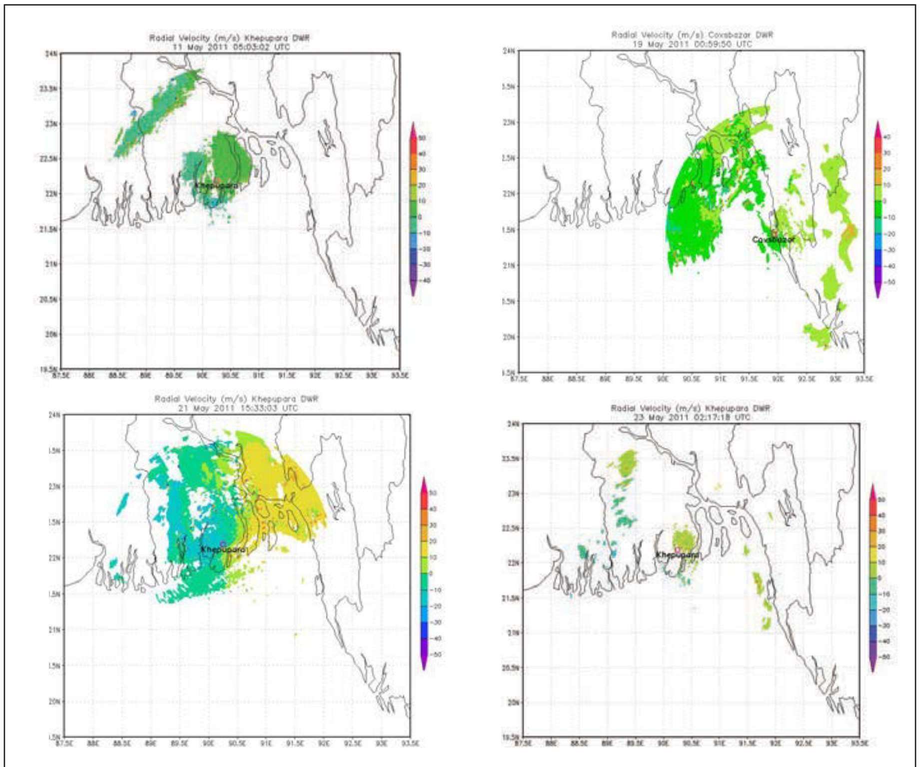
Fig. 2: The model domain under study with topography (shaded) in meters used for simulation and data assimilation

Radial velocity between -45 to 50m/sec is seen during those times (Figure 4, overleaf). A study of radar data shows that the Nor'westers propagate in the form of parallel bow-shaped squall lines having a horizontal length of more than 250km at the time of the occurrence of the squall.

Results and discussion

The WRF model was run for 24 hours to simulate the squalls close to the time of their observations. The results are presented below for 9km resolution. The idea is to diagnose the structures of the squalls using the model, and compare them with available observations from ground-based radar. The purpose is not to investigate the lead time of forecasting. The results presented correspond to the mature stage of the squalls as simulated by the model.

Fig. 3 (clockwise from top left): DWR derived reflectivity on (a) May 11, 2011 at 05:03 UTC; (b) May 19, 2011 at 00:59 UTC; (c) May 21, 2011 at 12:03 UTC; and (d) May 23, 2011 at 02:17 UTC.



T-phi gram analysis: convective available potential energy (CAPE)

Convective available potential energy (CAPE) is the positive buoyancy, which measures the instability of the atmosphere. As a rule of thumb, the following threshold values of CAPE are used to identify the instability of the atmosphere:

Weak instability: CAPE < 1,000J/kg

Moderate instability: 1000J/kg < CAPE < 2,500J/kg

Strong instability: CAPE > 2,500J/kg

Total Totals Index

Total Totals Index (TTI) is defined as follows:

TTI = T850 + Td850 - 2T500

Where T850 and T500 are the temperatures at 850hPa and 500hPa and Td850 is the dew point temperature at 850hPa. TTI is the combination of vertical totals, i.e. VT = T850-T500 and cross totals, i.e. CT = Td850-T500.

The following threshold values are being used to identify the occurrence of thunderstorm:

Indicator of occurrence of thunderstorm: TTI ≥40

Indicator of occurrence of thunderstorm with tornado intensity: TTI ≥47

The T-phi grams of all four cases showed instability in the atmosphere. The lifted indices were usually less than -3. When the

Table 1: Selected squalls and gusty wind events during May 2011 in Bangladesh					
Date	Reported station	Events type	Wind speed (km/h)	Wind direction	Reported time (UTC)
05/11/11	Rajshahi	Squall	41	W	0300-0330
	Dhaka	Gusty wind	56	W	0542-0544
	Chittagong	Squall	70	WNW	0932-0934
05/19/11	Chittagong MMO	Gusty wind	56	NW	100
	Chittagong PBO	Squall	44	NW	0530-0600
05/21/11	Dhaka MMO	Gusty wind	74	WNW	1209
	Dhaka PBO	Gusty wind	67	W	1215
	Faridpur	Gusty wind	56	NW	1230
	Patuakhali	Squall	59	NW	1400
	Chittagong MMO	Squall	80	N	1500-1530
05/23/11	Bogra	Squall	45	NW	0130-0200

"The WRF model was run for 24 hours to simulate the squalls close to the time of their observations"

LI values are between -3 and -6, the atmosphere is unstable with the possibility of severe thunderstorms (*Mercer et al., 2012*). TTI values above 40 are indicative of likelihood of severe thunderstorms. Values greater than 47 are indicative of severe thunderstorms with tornado intensity. When KI values are >30, it indicates possibility of thunderstorms. When it is >40, it indicates the possibility of severe convective activity (Table 2, previous page).

Sea level pressure (SLP) time series

Strong surface heating due to solar insolation causes the formation of low heat at the surface. SLP seems to be less than 1002hPa (Figure 5) over Dhaka due to the existence of low heat during the

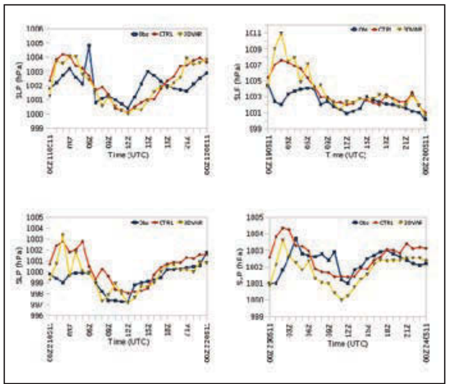


Fig. 4: DWR derived radial wind on (a) May 11, 2011 at 05:03 UTC; (b) May 19, 2011 at 00:59 UTC; (c) May 21, 2011 at 12:03 UTC; and (d) May 23, 2011 at 02:17 UTC

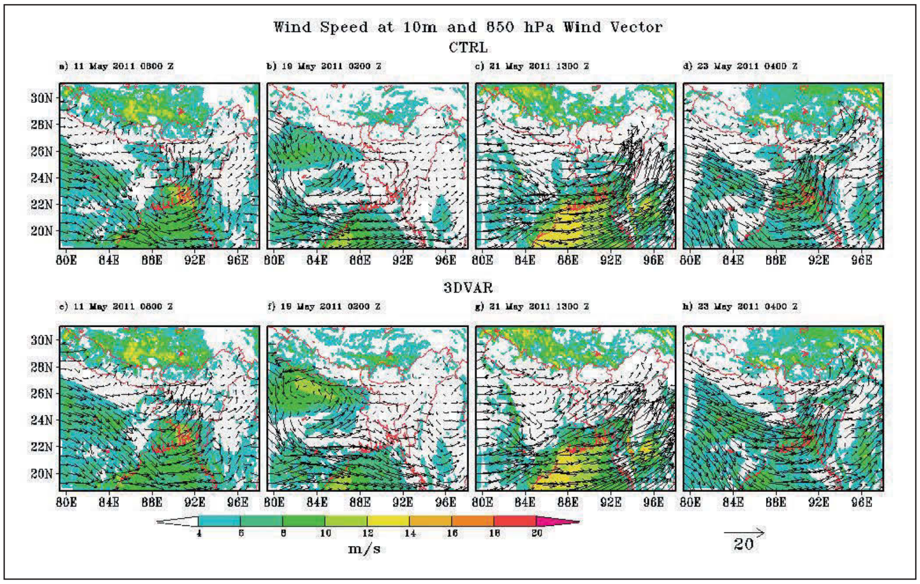


Fig. 5: Comparison of sea-level pressure (SLP) over Dhaka between observations from CTRL and 3DVAR (a) May 11, 2011; (b) May 19, 2011; (c) 21 May, 2011; and (d) 23 May, 2011

pre-monsoon. 3DVAR shows the pressure drop and increasing tendency due to convection, which is helpful for forecasting. The MSL pressures obtained from CTRL and 3DVAR runs do not always follow the observed values, but for some time 3DVAR is close to the observed value.

3DVAR shows some improvement of predictions in three (May 11, 21 and 23, 2011) out of four cases, i.e. RMSE values of the 3DVAR run are lower than for the CTRL run (Table 3, above left).

850hPa wind vector

The impact of 3DVAR assimilation upon the first 'guess' is studied here. It can be seen that the experimental 3DVAR runs have simulated 10m wind speed of about 12-14m/sec in small patches in the West Bengal region. Whereas the control run has produced 10m wind speed greater than 8m/sec over the region. There is a strong trough at 850hPa simulated by the 3DVAR; this is absent in the CTRL run (Figure 6). The 850hPa horizontal wind

Stability indices	Squall events	May 11, 2011	May 19, 2011	May 21, 2011	May 23, 2011
CAPE	Obs.	688.01	10.65	1837.68	1475.31
	CTRL	1498	54	1064	1899
	3DVAR	1451	154	1066	2050
Lifted index (LI)	Obs.	-5.53	-0.34	-5.74	-3.75
	CTRL	-8	0	-8	-5
	3DVAR	-8	-2	-5	-5
K index (KI)	Obs.	44	42.7	43.4	34.4
	CTRL	35	32	39	34
	3DVAR	38	35	40	34
Total Totals Index (TTI)	Obs.	57.7	47.8	48.9	42
	CTRL	52	42	50	43
	3DVAR	53	47	50	43
Precipitable water (mm)	Obs.	58.81	71.87	73.74	61.74
	CTRL	33.4	46.7	40.7	37.7
	3DVAR	33.8	46.8	43.1	37.9

Table 2: WRF-ARW Model simulated stability indices over Dhaka at 00:00 UTC for different cumulus schemes and 3DVAR

"There is a strong trough at 850hPa simulated by the 3DVAR; this is absent in the CTRL run"

Table 3: Analysis of CTRL and 3DVAR SLP (hPa) with BMD observations using statistical methods

Statistical analysis	Cases	CTRL	3DVAR
RMSE	May 11, 2011	1.2	1.17
	May 19, 2011	2.05	2.74
	May 21, 2011	1.53	1.14
	May 23, 2011	1.08	1.07

shows a trough and high wind velocity over the squall location. The phenomena are stronger in the 3DVAR run.

Vorticity at 950hPa

The low-level relative vorticity field at 950hPa is depicted in Figure 7. Positive values have been shaded. Pockets of positive vorticity of magnitude greater than $5x10^{-5}$/s are seen in most of the cases. The vorticity field is generated due to horizontal shear in the wind field and provides spin in the flow.

The strong low-level heating and a cooperative positive vorticity in the wind field acts as a trigger for the initial rise and growth of the thermals *(John et al., 2013).*

Basis for study

The simulated results provided a basis by which to study the microphysical and dynamic characteristics of squalls, which are generally not available from observations. The model could not simulate the bow-type squall lines as observed by the radar. The model underestimated the strength of the squall lines in general. The simulated wind speed at the surface was never more than about 25-30km/h.

The impact of data assimilation is clearly visible as the experimental simulations from the WRF-3DVAR are able to capture the squalls closer to the observations compared with the CTRL run. The position and intensity of the simulated squalls in the experimental runs is close to the observed values, as compared with the DWR derived products. ∎

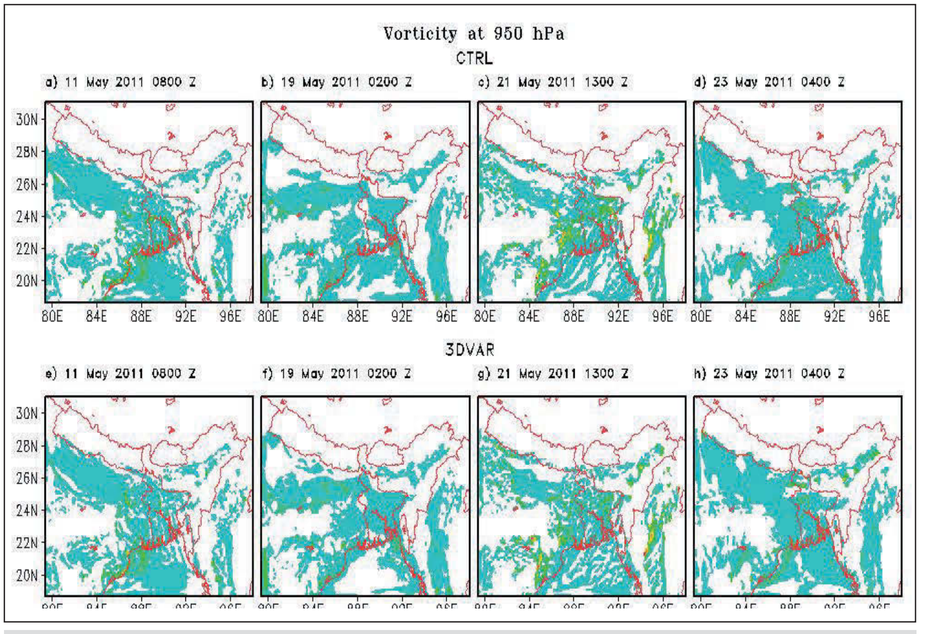


Fig. 6: Vector wind at 850hPa and 10m wind speed (m/sec) forecasts valid on the days of the squalls (a-d) CTRL and (e-h) 3DVAR run

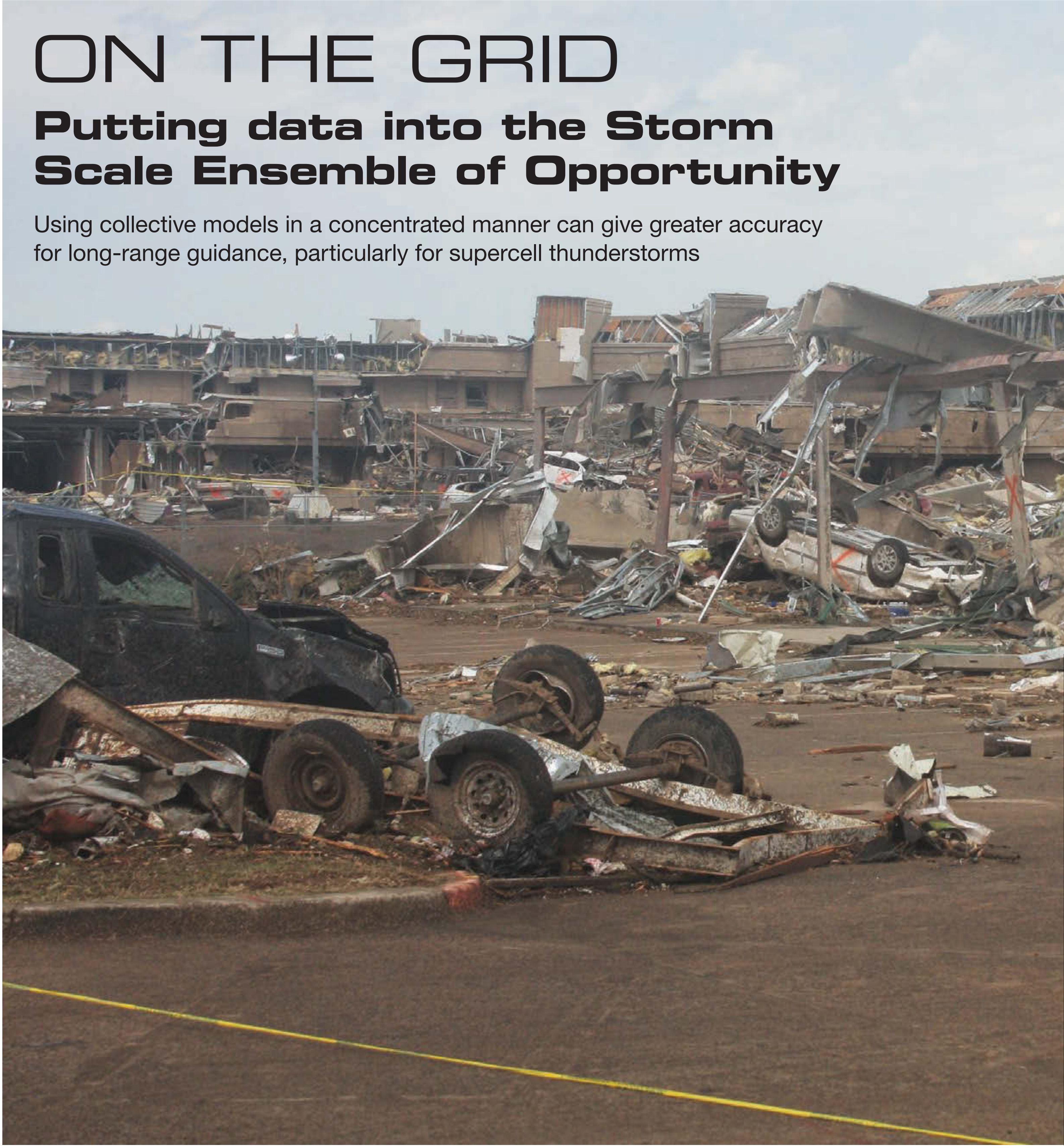
This article was written by Mohan K Das, with Abdul Mannan Chowdhury, Sujit K Debsarma and Someshwar Das, at SAARC Meteorological Research Centre (SMRC), Dhaka, Bangladesh; Jahangirnagar University, Savar, Bangladesh; and the National Centre for Medium Range Weather Forecasting (NCMRWF), NOIDA, India

by Harold Brooks

ON THE GRID

Putting data into the Storm Scale Ensemble of Opportunity

Using collective models in a concentrated manner can give greater accuracy for long-range guidance, particularly for supercell thunderstorms



STORM SCALE ENSEMBLE OF OPPORTUNITY

Information published through the American Meteorological Society in November 2012 by Israel L Jirak from NOAA says that given that the organization may not have the computing resources to generate a formal storm-scale ensemble system in the near future, the Storm Prediction Center (SPC) has developed the Storm Scale Ensemble of Opportunity (SSEO) as a practical alternative.

The SSEO is comprised of seven deterministic convection-allowing model runs already available to the SPC. The data is processed as an ensemble to generate ensemble fields such as mean, maximum and exceedance probabilities. A few select storm-attribute variables are included in the SSEO for severe weather forecasting, including hourly maximum fields (HMFs) of simulated reflectivity, updraft helicity, updraft speed, and 10m windspeed. In addition, other fields (e.g. precipitation and 2m temperature) are processed in the SSEO to assist with the fire weather and winter weather forecasting responsibilities of the SPC.

Initial development of the SSEO commenced in 2011 when it was tested for severe weather applications during the 2011 Spring Forecasting Experiment (SFE) held at the NOAA Hazardous Weather Testbed. More extensive evaluations, including subjective and objective verification, were conducted during the 2012 SFE. The fractions skill score (FSS) was calculated for the SSEO updraft helicity neighborhood probabilities relative to observations of severe weather reports. Similarly, the FSS was computed for the SSEO simulated reflectivity neighborhood probabilities as compared with observed radar reflectivity.

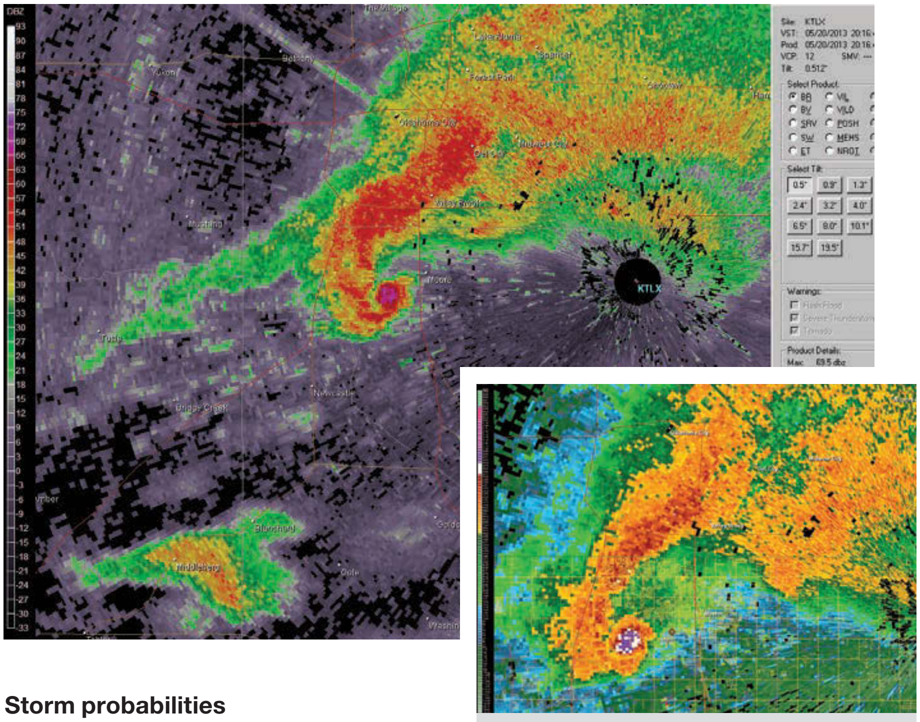
Numerical models provided tremendous value in the forecasting of the devastating tornado events that struck Oklahoma in May 2013. Twenty years ago, such guidance was impossible to consider. Operational models ran at a grid spacing of 100-200km, so that there would be only two to four grid points from north to south across the state of Oklahoma. This enabled forecasters to see the large-scale environments in which storms would form, but not to see the actual storms.

Now a number of institutions regularly run models at a 3-4km horizontal grid spacing that can simulate some of the characteristics of actual thunderstorms, and in particular the most severe thunderstorms, called supercells, from which strong and violent tornadoes can form. Supercells are characterized by rotating updrafts and have been studied in research settings since the 1970s. The USA's Storm Prediction Center (SPC) collects whichever models (typically seven) that are run starting at 00:00 UTC on a particular day and puts them together into the Storm Scale Ensemble of Opportunity (SSEO).

Supercell thunderstorms

Supercell thunderstorms are identified by large values of 'updraft helicity', a measure of rotating updrafts. While this feature does not directly show severe thunderstorms or tornadoes, research has shown it to be associated with severe thunderstorms. By combining the output of all the members of the SSEO and smoothing them over a series of grid points surrounding any location, the probability of high updraft helicity at any time across the country can be calculated. The resulting field is then smoothed as shown on the next page for May 20, 2013, at 21:00 UTC, shortly after an EF5 tornado entered Moore, Oklahoma, to arrive at a forecast probability within 40km of any location, similar to the Convective Outlook products put out by the SPC.

Probabilities from this guidance product exceeded 50% just south of Moore, shown by the star, with a large area greater than 30%. For comparison, climatological probabilities of severe thunderstorms over a 24-hour period are only a few percent at that time of year in that part of the USA. From guidance developed almost 24 hours prior to the violent tornado, the model indicated high probabilities in and to the south of the Oklahoma City metropolitan area.



Above: The reflectivity of the hook echo associated with the Moore tornado, when it's 3-4km south west of the Moore Medical Center

Left: A zoomed in look at the hook echo with the so-called debris ball signature near the time the tornado was rated EF5 at the Briarwood Elementary school (5km from Medical Center)

Storm probabilities

Clearly, there is great promise for relatively long-range guidance of high-impact events on small spatial scales from the SSEO. In this case, although the Oklahoma City metropolitan area was in the relatively high probability region, the highest probabilities were 50-100km south of the city. Even though this would be less than a grid point away in the models of 20 years ago, it is 12-25 grid points away in the modern models. Although there were marginally severe thunderstorms south of Oklahoma City, there were no tornadoes, let alone violent tornadoes. As a result, even though there was useful guidance for the biggest event, the guidance could still be seen as an overforecast of the event.

Where do we go from here? The historical increase in computer power has enabled models to resolve features that forecasters couldn't imagine seeing a short time ago. Assuming further increases in the future, many things could be done. Finer grid spacing would allow for better resolution of the thunderstorms and come closer to the scale of tornadoes. The membership of the ensemble could be increased dramatically. Currently the European Center for Medium-Range Weather Forecasting uses more than 100 members in its medium-range ensemble.

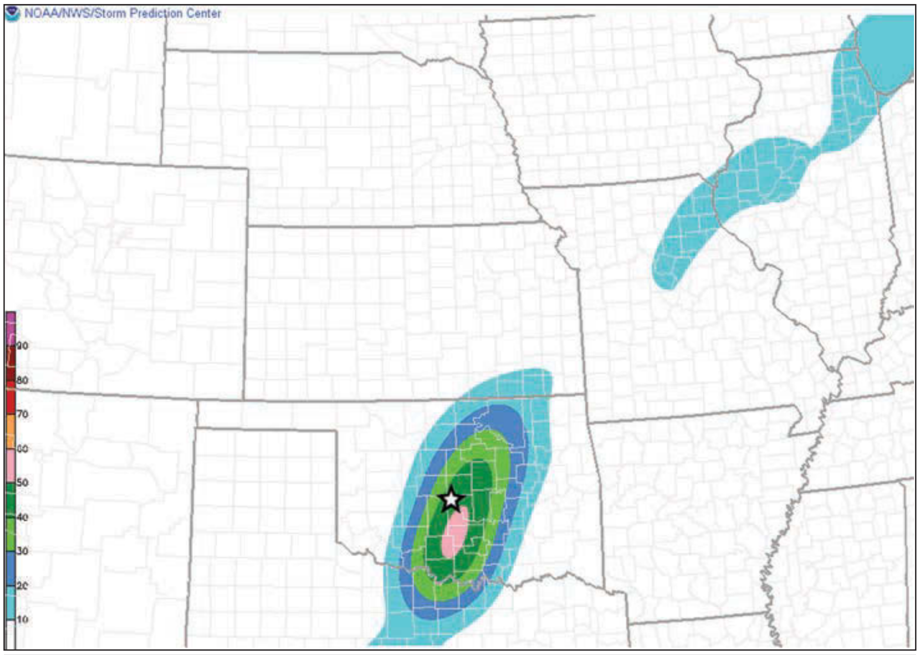
A larger ensemble would enable forecasters to get better information on the probability of events, as well as see potential high-impact, low-probability events. The initial state of the ensemble is also likely to change dramatically.

Different approaches

Currently, different models use individual initialization methods and physical parameterizations of unresolved processes. As part of the Warn-on-Forecast project led by scientists from the National Severe Storms Laboratory, systematic approaches to creating realistic uncertainties for initial conditions, using techniques such as the Ensemble Kalman Filter, are being explored, as well as the impacts of combinations of parameterizations to estimate the uncertainty of the evolution of the atmosphere more reliably.

In addition, the other revolution involves the assimilation of radar data in the initialization and integration of the ensemble. As operational radars evolve towards less than 1km resolution and one-minute update times, the volume of data and its automatic quality control present enormous challenges for future models. But the promise of highly reliable, frequently updated probabilistic forecast guidance for severe thunderstorms may be realized within as little as a decade. ∎

Harold Brooks is a research meteorologist and senior FRDD scientist at NOAA/National Severe Storms Laboratory, based in Norman, Oklahoma



Probability of large values of updraft helicity (associated with severe thunderstorms) within 40km of a point from Storm Scale Ensemble of Opportunity, initialized at 00:00 UTC May 20, 2013, valid 21:00 UTC May 20, 2013, near the time of the Moore, Oklahoma (indicated by star) EF5 tornado (Courtesy Greg Carbin, NWS)

QUITE SIMPLY THE BEST SHOW YET... THE MUST-ATTEND EXHIBITION DEDICATED TO WEATHER PREDICTION AND CLIMATE MEASUREMENT TECHNOLOGY SERVICES

Clockwise from top left: Aerosol warning system; polar temperature profiler; CVF4 ventilation unit; public forecast service; calibration equipment; Visual Rangers lidar system; SMART2000 telemetry system; and GIS layer graphic

Clockwise from left: Lightning range detector; GCOS manager Tim Oakley; digital globe; small weather radar; marine radar; Cyrena-Marie Briedé (Mt Washington); and ground wind profilers

METEOROLOGICAL TECHNOLOGY WORLD EXPO 2013 FEATURES 150+ EXHIBITORS AND MORE TECHNOLOGIES, NEW PRODUCT LAUNCHES AND CONFERENCE PAPERS THAN EVER BEFORE! RETURNING TO BRUSSELS, BELGIUM, OCTOBER 15–17, 2013, THE WORLD EXPO IS THE PLACE TO SEE THE LATEST TECHNOLOGIES FOR WEATHER PREDICTION, MODELING, AND ANALYSIS

The 2013 Meteorological Technology World Expo will be the largest event of its type in the world, and even better than last year's show, featuring over 150 exhibitors.

Held in the larger Hall 3 at Brussels Expo from October 15–17, 2013, the show will welcome companies specializing in every type of climate, weather and hydrometeorological forecasting, measurement, and analysis technology and equipment. Key decision makers from the fields of aviation, shipping, military operations, offshore exploration and more will be traveling from around the globe to keep abreast of the latest products and trends within the industry. See the following pages to sample some of the numerous never-seen-before technologies on display.

This year's Expo will also offer not just one but two fantastic free-to-attend conferences, with two constant streams and 70+ speakers covering aviation, modeling, simulation, agriculture, shipping, case studies, radar and airports.

There is also a new outside technology demonstration area (by the main entrance), which will feature some of the latest meteorology measurement and prediction technologies, with real-time weather information being reported live in the exhibition hall!

Register now on our website: www.meteorologicaltechnologyworldexpo.com to receive your free pass for this year's must-attend event. See you there!

NEW FOR 2013

OUTSIDE TECHNOLOGY DEMONSTRATION AREA

For the first time ever at Meteorological Technology World Expo, there will be a dedicated Outside Technology Demonstration Area, providing a unique chance to see innovations from leading lights including Metek, Leosphere and MeteoModem – 'in the field' and operating! Products on display will range from lidar developments to a fully operational Autosonde, with all measurements displayed inside the exhibition hall, just 20m away.

SEE THE ARCTIC ROBOTSONDE IN ACTION

MeteoModem, a leading manufacturer of upper-air sounding systems and associated radiosondes, will be showcasing its Robotsonde in the Outside Technology Demonstration Area. Christophe Raux is the product engineer for the company, which represents more than 40,000 radiosondes per year with 120 operational sites across all continents.

What have you been up to?
We recently developed a new concept of an unmanned upper-air sounding system – the Robotsonde. It has been designed to bring flexibility, efficiency and cost savings in the management of an upper-air station.

What are you launching and demonstrating at the show?
Meteorological Technology World Expo 2013 will be a great opportunity to exhibit the Arctic version of our Robotsonde, which has been successfully operated in Tasiilaq (Greenland) during a full year that included a Piteraq (Arctic tempest) episode. During the show visitors will be able to see the Robotsonde and a get a much better idea of its capabilities than is possible from brochures.

What makes the Robotsonde unique? And how does it relate to weather prediction?
The specificity of our Robotsonde consists in the choice of very simple technical solutions to prevent risk of failures and the necessity for major maintenance. Moreover, we have always kept a close watch on cost so that we could develop something 'affordable' for users.

NEW EXHIBITOR

TELEMETRY SYSTEM

First-time exhibitor Felix Technology is making the journey from its headquarters in Canada to demonstrate its new SMART2000 telemetry system – a high-tech acquisition, logging and control system based on an ARM microprocessor.

The RTU has eight isolated differential analog inputs enabling data acquisition up to 16 bits. It features six digital inputs/outputs that enable the user to control various sensors and auxiliary equipment. The system uses four digital interfaces – RS-232, RS-485, USB and Ethernet. The power supply is backed up by a rechargeable battery; a built-in charger ensures that it is fully charged. A power-down mode with a wake-up timer on external input allows the optimum use of battery power during an extensive operation. The data logger can be configured using software running under Windows 98/ME/NT/2000/XP/7.

STAND: 4030

POLLEN ANALYSIS

Helmut Hund of Germany will be demonstrating the first-ever fully automated pollen analysis system, BAA500, which has been designed to provide reliable real-time measurement of pollen concentration. "Air quality surveillance is not only a question of measuring contaminant gases and dust concentration, but also one of pollen concentration in the ambient as well, as a growing part of the population suffers from pollen allergies," it says.

The system uses a picture recognition unit based on a linear discriminant approach to analyze microscopic pictures generated in a robot microscope. This microscope gathers pictures of the pollen phase (particle size range 10-150μm) from ambient air collected in an impactor/separator taking in about 60m³ of air per hour.

In the discriminant approach a set of 122 features (numbers) is generated to describe the variety of properties seen in a given pollen picture. Subsequently, this feature vector serves to assign the picture to a cloud in the number space, which is spanned by the total of all features. During training procedures for the recognition system, which is performed by a human observer, the number space is divided into vector-clouds (classes) where each class stands for a single species of pollen. An unidentified sample is identified by finding the 'right' cloud.

STAND 2046

NEW!

NEW!

MARINE RADAR SOLUTION

Furuno Electric is traveling from Japan to introduce its latest and most innovative weather radar solutions at the Expo. "Marine radar requires stable and accurate target detection as well as identification performance under various weather and sea conditions," explains Yoshiaki Takechi, Furono's chief engineer. "It has to be able to distinguish a range of floating objects, including small boats, driftwood and buoys. Having accumulated extensive technical know-how through our experience in developing marine radar, Furono has developed a new compact X-band dual polarimetric Doppler weather radar WR-2100 and X-band Doppler weather radar WR-50."

The WR-2100 enables a user to examine precipitation in the atmosphere, monitoring the intensity and speed of precipitation as well as differentiating various types of precipitation. The WR-2100 is a very compact and lightweight weather radar sensor with a radome diameter of 108cm, height of 102cm, and weighing 65kg. The compact and lightweight sensor facilitates remarkable cost cutting when it comes to installation on the monitoring sites as well as in monitoring operations.

Furono will also introduce its new 3D compact X-band weather radar system, which uses an integrated radar network to conduct extreme weather observation in urban areas, presenting a detailed real-time 3D illustration of accumulated rainfall, with wind direction and strength.

STAND: 3055

CONFERENCE SPEAKER

IN FOCUS:

CYRENA-MARIE BRIEDÉ

director of Summit Operations at the Mount Washington Observatory

What is your part in enhancing weather prediction?
Not only do we make hourly observations of many meteorological parameters that contribute to forecast models, but we participate in research projects with our regional 18-station mesonet to better understand the sensors we are using, the data we are collecting, and how the data can be better employed.

What are you discussing?
I want to introduce the Mount Washington Observatory and its capabilities and potential to the international meteorological community.

Why is this important? What is new?
We have a unique climate record that is over 80 years old. We make our measurements today by human observers using the same methods, instruments and location as we have since 1932, which is rare to find in the USA. We can also provide customers with arctic testing conditions without the cost of traveling to the ends of the earth.

Are there obstacles you see regarding the future of weather prediction in your field?
I hope research efforts to learn as much as we can about our weather and climate don't fade any time soon. We know so little about our environment and atmosphere and have some great discoveries coming in our future.

Within your expertise, what do you see as the next technological stage in weather prediction?
I think the next level is to improve terrain data in forecast models. As computing power and technology increase, I look forward to seeing accurate terrain data at much higher resolution integrated into models. For example Mount Washington will then be seen as a summit 1,917m high rather than being averaged over a wide area and appearing a fraction of that height. Forecasts will continue to improve as the data we give the models improves.

What is the best thing about what you do?
Working for an organization whose mission is weather observations, research and education is a dream come true. We live and work in extreme weather on a daily basis at the Mount Washington Observatory because we care about data quality, data collection, research and educating others about weather and climate. It's so rewarding to be an integral part of advancing the meteorological community's knowledge of our earth systems.

SECOND OPINION

Calibration equipment

Looking for a reliable calibration kit? Theodor Friedrichs, a producer of high-quality meteorological sensors, will also display its range of calibration equipment for all kinds of meteorological sensors.

"Calibration is critical, as it is essential to know that your data is reliable," says a company spokesperson. "Every meteorological network operator should take care of its data and should question whether sensors are still producing reliable data after working for some seasons in changing temperatures and air pollution."

Calibration equipment provided includes pressure chambers, wind tunnels, rain gauge test equipment, and temperature and humidity test cabinets – all for mobile, laboratory and automatic use.

STAND: 3035

EXHIBITOR SPOTLIGHT

NEW FMCW RADAR LAUNCH

NEW!

MetaSensing, another first-time exhibitor, will display a brand-new FMCW X-band fully polarimetric Doppler weather radar. "During the Expo, we will introduce the MetaXWR, which is the prototype that will launch MetaSensing into the weather sector," says Simone Placidi, MetaSensing's atmospheric radar analyst.

"With our experience in FMCW radar in other applications, last year we started to use advanced know-how in FMCW radar to develop a high-resolution polarimetric Doppler FMCW radar with low-transmitted power for precipitation monitoring in urban areas. Compared with existing weather radars, the MetaXWR is unique because it transmits two linear polarizations at low power and has a high spatial resolution, which are all advantageous when monitoring precipitation in a city at street level. The use of this radar will help water-management authorities take responsive measurements to prevent floods caused by more frequent extreme weather events. The introduction of the dual-polarized weather radar enables more accurate categorization and estimates of the precipitation, especially in urban areas where clutter can be removed by the use of polarimetry and narrow-beam antennas," concludes Placidi.

"We are looking forward to introducing our solution to the meteorological user community in Brussels and improving MetaXWR following their needs and wishes," adds Dr Adriano Meta, founder of MetaSensing.

STAND: 7060

CONFERENCE SPEAKER

IN FOCUS:

SARA SUMMERS

meteorologist at the National Oceanic and Atmospheric Administration's (NOAA) Earth System Research Laboratory in Boulder, Colorado

Sara Summers is the European manager for NOAA's Science On a Sphere (SOS), providing support for the UK and European SOS network. Summers is speaking on the first day of the conference, Tuesday, October 15, delivering a paper entitled: 'Using NOAA's Science On a Sphere for science education'.

"SOS is a science visualization tool invented by one of NOAA's leading scientists, whose aim was to help the general population better understand weather and climate, atmospheric and oceanic processes, and the human impact on planet Earth and its environment," explains Summers. "The result was a 1.73m spherical display system that animates complex Earth system processes, and enhances NOAA's research and weather prediction. SOS is a versatile educational platform that displays real-time global weather, tsunami, hurricanes, lightning strikes, sea ice concentrations, sea level rise and climate models, to list a few topics in the library of 400 animated datasets."

Summers will be discussing one of the challenges currently facing the science community, namely, how to successfully communicate science in an understandable, impactful and memorable way. "Visualization is known to be a powerful educational tool and SOS technology is a method that has proved successful in this regard, with systems installed in 16 countries," she says.

"SOS technology is being used to enhance NOAA's weather prediction capability. A video news clip of hurricane Sandy's storm track will be shown. This was taken at the Aquarium of the Pacific in Long Beach, California, where near real-time satellite images of Sandy's path and intensity were captured on SOS and recorded by the local news channel, bringing a very real forecast to the general public.

"I hope to demonstrate SOS as an alternative to flat screen displays, in order to make weather forecasts more understandable to the general public – which is particularly important in the case of severe weather forecasts, watches and warnings. I will also profile some of our partnerships with museums, science centres, planetariums and other places of interest that have helped make SOS technology available to the public."

VENTILATION PRECISION

Kipp & Zonen will exclusively debut its new CVF4 ventilation unit during the Expo. CVF4 uses the latest flow management techniques to improve the performance of pyranometers and pyrgeometers, and was developed using micro flow and temperature measurement devices, as well as flow simulation software.

The flow is very high and swirls to improve air distribution over the dome. The heater power necessary has been reduced and improvements have been made for easier installation, use and maintenance. Visitors will be able to watch an animated video of the airflow on Kipp & Zonen's booth, as well as view the instrument itself.

The ventilation unit replaces the successful CVF 3 model and can be used with all Kipp & Zonen pyranometers and pyrgeometers in all weather conditions. Ventilation of radiometers improves the reliability and accuracy of measurement by reducing dust and dirt on the dome, removing dew and rain droplets, and melting frost and snow.

STAND: 4060

NEW!

FACT

The average temperature in Brussels in October is 12°C (53°F). Rainfall average is 70mm for the month on 19 days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PIN-POINT TENKI

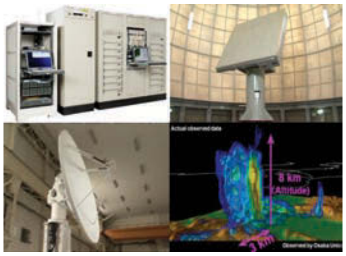
Toshiba Corporation and Zenrin DataCom will demonstrate a public weather forecasting service for cell phones, called Pin-Point Tenki (weather), providing forecasting information in a Japan-wide 5km mesh.

"With this high-density mesh size, with 76,083 forecasting locations, users will be able to know the weather difference between home and office," says a company spokesperson. "The service provides hourly/daily/weekly forecast information including the latest radar information."

The service incorporates the latest weather radar data into the forecasting model. The company says that this enables more frequent weather forecast updates and more precise short-term forecasting, especially within three-hour blocks. Since radar data updates every 10 minutes, the model provides more realistic results.

Two key technologies have been used to increase the precision of radar data: Solid-State Weather Radar (SSWR) and Phased-Array Weather Radar (PAWR). SSWR uses state-of-the-art solid-state transmitters, which provide high-quality dual-polarization data with a shorter observation time than magnetron or klystron radars.

Severe weather phenomena such as localized heavy rainfall, gusts and tornadoes are mainly caused by the rapid growth of cumulonimbus clouds at altitudes over 10km. The life of such clouds is as



short as 10-30 minutes. However, conventional parabolic weather radars require 5-10 minutes for full 3D volume scanning. In order to achieve precise 3D observations to predict severe weather, radar observations need to complete within one minute. Japanese commuters will be relieved to learn that the X-band PAWR completes this process in as little as 10-30 seconds.

STAND: 3004

CONFERENCE SPEAKER

IN FOCUS:

STEVEN R ALBERSHEIM

senior meteorologist, FAA

Steven R Albersheim is the international aviation weather program leader with the FAA's NEXTGEN Aviation Weather Division. His responsibility at the FAA is to promote global harmonization in the provision of meteorological services in support of international air navigation.

Albersheim's presentation, 'Changes in meteorological services in support of international air navigation', is scheduled for the first day of the conference (Tuesday, October 15). "I will be discussing the scheduled implementation of Amendment 76 to Annex 3, Meteorological Services for International Air Navigation [November 2013], which will bring changes in the World Area Forecast System with the addition of global gridded forecasts for cumulonimbus clouds, turbulence and icing. These forecasts will benefit global flight planners and operators. The presentation will also highlight the outcome of the 12th ICAO Air Navigation Conference with the adoption of the Aviation System Block Upgrades, with an emphasis on meteorological services. Key to this is global harmonization and the interoperability of meteorological services supporting a global ATM system." It will also include information about the planned introduction of space weather to Annex 3, and the outcome of the ICAO Volcanic Ash Task Force will be discussed.

"By the end of the presentation, hopefully those in attendance will have a better understanding of the changes that are proposed in the provision of aviation meteorological information in support of performance-based operations, not only for flight planning but also in the provision of in-flight hazards," continues Albersheim.

The discussion includes the need to improve the seamless exchange of meteorological information, development of single global standards for aviation weather information for observations and forecasts, and translation of meteorological information for use in decision-support tools by air traffic management.

BIG FLEET WEATHER DATA

NEW!

Stand by for something big from Weather Telematics, which plans to entice visitors with "a new paradigm of mobile traffic data, generated by vehicle probes, which promises to deliver an order of magnitude improvement in the quality and extent of weather-related data". The company believes that "the combined impact of telematics technology will change forecasting forever".

The Canadian company currently operates the largest mobile weather observation network in the USA, where it delivers millions of observations daily to NOAA's National Weather Service (NWS). Meanwhile, the world's largest package delivery company has also been testing the use of this telematics-based weather platform for over a year in the belief that it will help its operations benefit from better road weather information, such as black ice detection, road traction alerts and road condition reports.

"If a single vehicle can deliver 2,500 observations daily, just imagine the amount of data delivered by a fleet network of over 100,000 vehicles globally," says Bob Moran, Weather Telematics' CEO. "Observations of this magnitude would provide a mobile backbone that would complement the current fixed weather infrastructure. The combined weather data sources would be broadcast in the form of real-time road weather hazard alerts to federal agencies, commercial industry sectors and the public alike. At highway speeds, a mobile platform can take 2,500 observations a day while covering approximately 500km."

STAND: 6010

FACT

Launched in 2011 to universal industry acclaim, the World Expo will attract more than 150 exhibitors and around 2,500 attendees in 2013

SMALL WIND VELOCITY WONDER

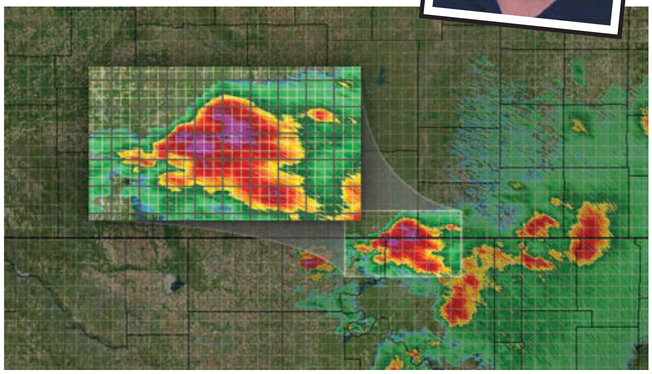
GAMIC will present its GMWR-25-SP system – the only small weather radar on the market that provides Doppler wind-velocity measurement. It is available in single- and dual-polarization versions; and is available in stationary and mobile versions; with the company claiming it "costs less than half of a conventional X-band weather radar".

GMWR-25-SP also uses the most up-to-date Doppler technology available for magnetron radar systems, including a proven design concept used in ship radar transceivers, which are deployed in large numbers all over the world. The Magnetron transmitter delivers 25kW output power from a fully solid-state modulator and power supply. It has an integrated optimized low-noise Doppler receiver front end and digital IF-signal processor-receiver.

STAND: 3010

EXHIBITOR SPOTLIGHT

WEATHER EFFECTS ON THE POWER GRID



Baron Services will promote PowerNet as an innovative solution to leverage weather forecasting capabilities to help optimize electric system operations, lower outage times and increase revenues.

"There are several points at which severe weather can impact the operations of electrical utilities – one is at the generation facilities, and another is at transmission and distribution facilities and lines," explains Baron's David Widener. "Knowing how power systems load, the combination of the generation resources that are available, and how the expected weather affects the systems, can mean all the difference between whether the lights stay on or not. When a severe storm containing straight-line winds, a tornado, or even lightning damages facilities or lines, a little warning can help everyone from the engineers to station crews to be in the best position for quick restoration."

PowerNet uses radar data, satellite data, meteorologic and hydrometeorologic reporting stations, and weather sonde readings to provide guidance on near-time (0-2 hours in the future) weather conditions. It can also provide additional guidance up to eight hours in the future. The sensor inputs and model outputs are evaluated and risk analyses performed against power-related assets and interests. These evaluations are turned into high-resolution graphical decision-support information that shows the risk analysis as a GIS layer superimposed on customer-owned assets and interests, such as generation facilities, buildings, and transmission and distribution facilities and high-resolution based maps.

"Staying weather-aware is vital to efficient electric system operations and risk assessment. An advanced system and fully integrated data collection from a variety of sources is key," says Widener.

STAND: 5005

ARCTIC RESULTS

Exclusive study results

Visitors interested in the latest thermal studies of the polar atmospheric boundary layer (ABL) should stop by RPO Attex's booth, where a number of exclusive studies will be available. These have been obtained during expeditions conducted by the Arctic and Antarctic Research Institute on the Russian drifting ice stations 'North Pole – 39' and 'North Pole – 40' from April 2012 to June 2013. The measurements were provided by RPO Attex's new MTP-5 PE temperature profilers. "With MTP-5 PE, scientists obtained continuous temperature profile data during 14 months of drift, over more than 2,000km in the Canadian sector of the Arctic Basin," says a company spokesperson. "With climate change it is clearly necessary to conduct scientific investigations at the polar regions, which requires instruments with special capabilities. Such instruments must reliably produce representative data at a wide range of temperatures, and be capable of being unmanned during all weather conditions. MTP-5 PE enables atmospheric temperatures to be recorded every five minutes at multiple levels up to 1,000m above ground level with spatial resolution of 10m for the first 100m."

STAND: 7120


Biral
www.biral.com
Thunderstorm Detector
Thunderstorm and lightning detection
· Stand Alone Range & Direction Sensor
· Unique Quasi Electrostatic Detection
· High Detection Efficiency
· Very Low False Detection Rate
· No Moving Parts
· Detects cloud-to-ground and intra-cloud flashes
· High Immunity to man-made radio interference
· Designed to FAA and BSEN 50536:2011
· Warns of lightning risk
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enquiries@biral.com
+44 (0)1275 847 787

NEW EXHIBITOR

AGRO-METEOROLOGICAL AND URBAN WEATHER STATIONS

Making its first appearance at the show, Eurelettronica ICAS is a specialist in providing regional networks of automatic weather stations. Its comprehensive services included site preparation, installation, technical training and after-sales maintenance.

Expo visitors can learn more about one of the Italian company's recent projects, involving the installation of 49 complete weather stations. Further stations were added to bring the total number to 72.

The meteorological equipment was manufactured by Vaisala and Kipp & Zonen – two of the companies represented by Eurelettronica ICAS in Italy. Cooperation between the customer and the manufacturer to use GSM-GPRS telemetry and the FTP protocol, enabled the customer to cut costs and avoid investment in network infrastructure.

Following installation and startup, Eurelettronica ICAS implemented a preventative maintenance program, extending the life of the equipment, maximizing uptime, ensuring high-quality data without interruptions, and minimizing the need for repairs and spare parts.

STAND: 4054

FACT

The exhibition is free-to-attend, with two constant conference streams and more than 70 speakers covering aviation, modeling, simulation, agriculture, shipping, case studies, radar and airports

SOUNDING OFF FOR DATA

Vaisala will present a fourth-generation sounding system, designed using internet-age, user-centric design principles. Seventeen end-users from 11 sounding stations in five countries have contributed to the evaluation and design of a new, user-friendly system. As an example, the preparation of the radiosonde can be conducted with minimal interaction with the computer keyboard and mouse, and the variation due to operator has been minimized to ensure constant, high-quality data. The modern sounding system enables remote control and operation over a TCP/IP network. This allows the meteorological organization to work in its mode of choice, performing the post-launch monitoring of the sounding either locally, over the network, or by letting the system finalize the observation completely independently without monitoring.

STAND: 5002

CONFERENCE SPEAKER

IN FOCUS:

TIM OAKLEY

implementation manager for the Global Climate Observing System (GCOS)

"GCOS is a long-term, user-driven operational system capable of providing the comprehensive observations required for monitoring the climate system, and my role is to initiate and manage projects to ensure data availability on a global scale," explains Tim Oakley, implementation manager for the Global Climate Observing System (GCOS), and speaking on the first day of the mainstream conference (Tuesday, October 15).

"The GCOS program is sponsored by three UN bodies – WMO, IOC of UNESCO and UNEP, and by the International Council for Sciences [ICSU]," he continues. "This multiple sponsorship guarantees that we cover the broad range of climate information required on a global scale and that our work is supported by the international community. In order to understand where our climate is headed, we need to know where it has been in the past and where it is now, and our observational networks are critical in helping to answer these questions."

Oakley describes his role as similar to an international network manager. "My role involves linking funding from our sponsors to priority areas, both in terms of the uniqueness of measurement – meaning its location and content – and the financial challenges for the host organization in operating the equipment," he explains. "GCOS does not own any of the observing equipment but through the GCM [GCOS Cooperation Mechanism] it aims to support national services and institutes in the design, installation and operational management of their systems. Just providing a voice at the end of a telephone line – or these days an email reply – can make such a difference in keeping these systems running.

"Industry provides a major role in the complex cycle of observing systems. It is having manufacturers in the field, and with their own equipment, that is one of the key components of long-term success in operating observing equipment.

"High-quality measurement and sustainability are fundamental in support of climate services and only by collaborating with industry can GCOS, and national owners, hope to meet the challenges of the climate."

Aviation safety

VISUAL RANGERS FOR AVIATION

Raymetrics believes its Visual Rangers have the potential to provide a wealth of new information to several industries, particularly aviation. To prove the point, it will demonstrate its latest lidar technique, enabling measurement for the first time of slant visual range (SVR), i.e. remote visibility in the direction the pilot sees the runway. Current technology usually provides only runway visual range (RVR) – visibility in-situ at ground level.

Visual Rangers can also provide other important information. In 2012 Raymetrics worked with Meteo France to trial its system for detecting incoming fog banks. Fog is a major problem at many airports around the world. Meteo France therefore sought out a solution that would enable automated detection of fog and could also provide an estimated time at which the fog bank would reach the airport. The trial is ongoing but initial results have been positive. A second major trial will begin in winter 2013 at Athens International Airport.

In 2012 Visual Rangers received an ISO from the International Standards Organization in 2012, as they are expected to become the next generation of visibility measurement tool. With multiple functions available (slant visual range, fog detection, 3D cloud base, and, with a minor upgrade, volcanic ash detection), Visual Rangers may soon become an essential piece of aviation equipment.

Lidar is a relatively mature technology that is only now becoming widely known as a solution. New technology in the marketplace is creating new applications, including visual ranging.

STAND: 2060

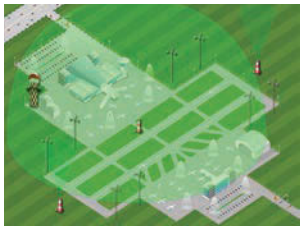
MORE FLIGHTS, MORE SAFETY

NEW!

International Aero Navigation Systems Concern (IANS) will reveal its latest WINDEX lidar wind profiler, which performs remote measurements and receives information including wind speed and direction at different altitudes; windshear; vertical gusts; and ambient turbulence. Each lidar system can be individually configured for a specific aerodrome's requirements. Inclusion of WINDEX-5000 in LLWAS provides additional geo-referenced and runway referenced 3D information about gust front altitude position.

"When a dangerous meteorological event such as windshear or severe turbulence is detected WINDEX automatically transmits warnings to the airport's meteorological and ATC services," explains a company spokesperson. "Such ground-based technical tools for remote monitoring of meteorological conditions near a runway are key to improving safety."

STAND: 4020



CONFERENCE SPEAKER

IN FOCUS:

JAN PARFINIEWICZ

chief specialist at the Institute of Meteorology and Water Management, Meteorological Services for Civil Aviation (MOLC)

Jan Parfiniewicz is one of the key speakers at Meteorological Technology World Expo and a leading expert in storm prediction for the Institute of Meteorology and Water Management at MOLC, based in Poland

What is your part in enhancing weather prediction?
I am responsible for developing methodology and operational software for meteorological forecasting offices within MOLC. The products of our work can be found on our website [http://awiacja.imgw.pl/en/] and include charts for wind, turbulence, icing and thunderstorms. All were developed and are managed directly by me.

What are you discussing?
My presentation will include the themes of forecasting thunderstorms and nowcasting strong convective events.

What is it about the technology that you find groundbreaking?
The new approach is mostly around the Thunderstorm Thermometer, which allows users to see the thunder cell development in the context of its perceptible destructive effects.

Are there obstacles you see regarding the future of prediction in your field?
The potential of hydrodynamic models as a tool for deterministic weather forecasting is being virtually exhausted. New complex systems must be formed. The management of these systems is a challenge for today.

Within your expertise, what do you see as the next technological stage in weather prediction?
I have been involved in numerical weather prediction from early developments in 1972 to the sophisticated applications of today, starting with Professor L S Gandin. My vision is to implement self-learning algorithms into the bodies of the models, changing the way we are forecasting the weather.

What is the element that you find most satisfying with regard to what you do?
In my research I have always attempted to choose my own ways rather than follow frequented tracks. Sometimes they appeared to be a dead end, but I have always most enjoyed the intellectual challenge. I believe that following the principles of innovation and continuous self-questioning, I have managed to stay at the forefront of development in the industry in my country over the past 40 years.

MICRO PULSE LIDAR (MPL) FOR FORECASTING AND AVIATION SAFETY

Sigma Space's Micro Pulse Lidar (MPL) is set to generate a lot of interest at the Expo. A laser remote-sensing system, MPL provides continuous, unattended monitoring of the profiles and optical properties of clouds and aerosols in the atmosphere. Based on the same principle as radar, MPL transmits laser pulses that reflect off particles in the atmosphere. MPL then measures the intensity of backscattered light using photon-counting detectors, and transforms the signal into atmospheric data in real time.

Sigma Space offers two versions of Micro Pulse Lidar, both of which will be on display: MPL, for automated observation of aerosols and clouds up to 25km; and MiniMPL, for near-range atmospheric observation up to 15km.

MPL's vertically resolved, ground-based measurements provide detailed information about cloud height, extent and structure. These properties are key to forecasting because they are directly related to atmospheric processes below and within the clouds. What's more, using cloud height, optical thickness and signal depolarization, SigmaMPL software quickly and accurately classifies cloud types and structures, such as stratocumulus and cirrus. With the polarization feature MPLs can differentiate between spherical and non-spherical aerosols. To do this, MPL transmits light with a specific polarization state. Spherical droplets backscatter light without changing its polarization, while asymmetrical ice and ash particles depolarize part of the backscatter.

STAND: 2055

EXHIBITOR SPOTLIGHT

WIND PROFILING RADAR SYSTEMS

ATRAD is a leading developer and supplier of ground-based wind-profiling radar systems for measuring atmospheric phenomena such as wind velocities and turbulence. "We attended the Meteorological Technology World Expo in 2012 and soon realized that it is the premier event in the industry. That is why this year we are back as exhibitors. We are also very excited to showcase our wind profilers and other systems to the European and global markets," said Fernando Felquer, the company's business development manager. "Over the past few years we have been working hard on developing a new UHF Doppler wind profiler. This system will operate in the low UHF frequency band and will be able to be customized over a wide range of frequencies. This will make the system compliant with radio frequency licensing requirements worldwide."

ATRAD will also be exhibiting other wind profiler solutions such as its spaced-antenna based boundary layer radar (BLR12/27), which is deployed at numerous sites throughout Australia as part of the Australian Government Bureau of Meteorology wind profiler network, and its powerful stratospheric-tropospheric Doppler wind profilers (ST40 and ST80) which have been installed worldwide.

"In addition to our meteorological solutions, ATRAD is a leader in scientific radar solutions including ionospheric and meteor detection radars. We have developed a modular systems architecture, which simplifies the implementation of customized complex operational radar systems and subsystems. Over the past 18 years the company has supplied systems, components and expertise for over 70 major radar installations worldwide."

STAND: 3100

NEW!

THUNDERSTORM DETECTOR

A new instrument for detecting the range and direction of lightning flashes up to approximately 60km away will be presented by Biral. Real-time information on the proximity of lightning is required to minimise the risks associated with activities wherever aviation, sensitive electronics, explosive materials or people are exposed to the effects of a direct or nearby lightning strike. Knowledge of lightning activity is also used to monitor hazardous weather by national weather services, primarily for civil protection and to provide advice to the aviation community.

The Biral thunderstorm detector uses a novel method of discriminating between lightning and non-lightning sources of quasi-electrostatic field change. In addition to detection of all types of lightning within range, the system can also detect and classify other sources of rapid electric field change associated with thunderstorm or shower cloud activity, such as from nearby corona brush discharge, strong space charge variability and charged precipitation. Real-time lightning-flash detection and ranging combined with monitoring of initial storm electrification processes provides a comprehensive method of local severe weather warning. Since the operating frequency of the Biral thunderstorm detector lies below man-made sources of radio signals, the instrument is considered especially useful for sites with strong radio interference.

STAND: 5083

CLOUD-BASED DATA COLLECTION

Campbell Scientific will highlight its range of optical sensors, while also launching Konect GDS – a new cloud-based data-collection, archiving and online display system.

With a reputation for reliable and power-efficient products, Campbell Scientific's meteorological measurement instruments have been field-proven in challenging environments around the world. Its dataloggers provide extensive measurement and control functionality and are fully programmable to adapt to virtually any system application. CS Loggers provide onboard data processing and storage and support a wide choice of direct or remote communication options for data retrieval. The company will have a full range of optical products on display, including the CS135 ceilometer, capable of reporting four cloud layers at heights of up to 10km at a minimum resolution of 5m.

The PWS100 weather sensor is also expected to star at the show. This patented four-beam system sensor accurately reports precipitation values including rainfall intensity, drop-size distribution and accumulation, and also classifies the precipitation type, outputting the information as WMO present weather codes or METARs.

The brand-new CS125 will also be on display; it is similar to the CS120 but with added basic present weather capabilities.

Another new sensor is the CS140 background luminance sensor, which provides the luminance data required to assess the visibility range for lights such as runway and warning lights.

STAND: 4000

WEATHER ON THE WEB

Visitors to the show will be able to sample first hand Weather Underground's latest mobile weather products, including the newly released, and unique WunderMap tablet app.

Weather Underground became the world's first weather website after being founded in 1995, and has since been committed to delivering the most comprehensive, reliable weather information available. Weather Underground's unique personal weather station network has developed into the largest network in the world, with over 30,000 reporting stations. Personal weather station owners are considered Weather Underground's very own 'backyard meteorologists', and have assisted in the development of its proprietary BestForecast forecasting system. To create the most precise forecast, BestForecast uses the most innovative weather forecasting models and cross-verifies output with the localized data points from weather stations in the network.

With the app, users can tap into any of the 30,000 personal weather stations in the Weather Underground network.

STAND: 6002

CONFERENCE SPEAKER

IN FOCUS:

TOM BLEES

president of The Science Council for Global Initiatives

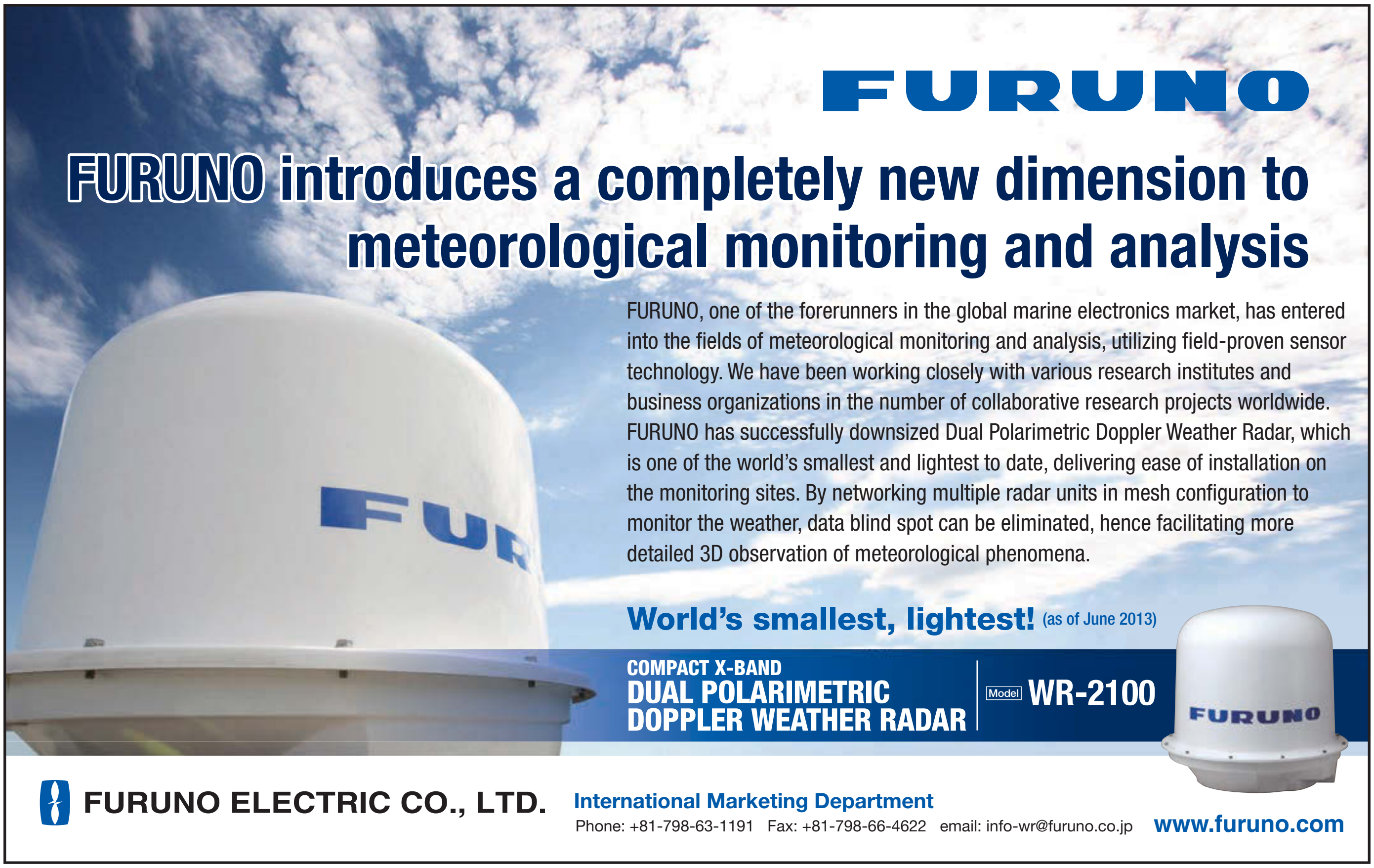
The Science Council for Global Initiatives is an international think tank made up primarily of scientists, many of whom were the developers of a revolutionary system of nuclear fission that is now ready to be deployed. Tom Blees is president and says: "While this is not related to weather forecasting *per se*, it is most definitely related to climate because this single system can provide all the carbon-free energy that humanity needs for nearly a thousand years, with fuel that is already out of the ground and currently considered waste. As improbable as this sounds, it is absolutely true that we have nearly a millennium worth of fuel at hand that is even better than free, as countries will gladly pay to be rid of it.

"My presentation in Brussels will look at the various options and make the case that so-called 'renewables' simply can not even come close to providing the energy that humanity demands today, and the even greater amounts that will be needed as developing countries continue to industrialize and raise their general standard of living," explains Blees.

The topic of climate change is always in the news, and meteorologists and those in related fields find themselves discussing it both privately and in very public appearances such as on the nightly news. Because of this, it's important to be aware of an actual solution to the problem, an energy system that can eliminate greenhouse gas emissions and can be deployed worldwide before mid-century.

Blees continues: "We're all aware of the universal hand-wringing that goes on over policy decisions aiming to solve the climate change problem. Advocates of wind and solar power spar with nuclear power promoters, and fossil-fuel interests spar with everybody. Attendees at the show will be told about international efforts and negotiations that are underway, and the progress being made toward initiating a global energy revolution based on the technology of the Integral Fast Reactor (IFR). The ability of this system to provide sufficient energy to produce abundant fresh water through desalination – as well as the energy to move that water to where it is needed – will be discussed. Again, this may seem only tangentially related to meteorology, yet precipitation and water supply are some of the most important aspects of that field, and this is the way we're going to be able to provide water for the predicted two or three billion increase in population that is expected by mid-century.


CRAY
CS300
Cluster Supercomputers from Cray
Come visit us at the Meteorological Technology
World Expo 2013, Booth 3090
www.cray.com


FURUNO
FURUNO introduces a completely new dimension to meteorological monitoring and analysis
FURUNO, one of the forerunners in the global marine electronics market, has entered into the fields of meteorological monitoring and analysis, utilizing field-proven sensor technology. We have been working closely with various research institutes and business organizations in the number of collaborative research projects worldwide. FURUNO has successfully downsized Dual Polarimetric Doppler Weather Radar, which is one of the world's smallest and lightest to date, delivering ease of installation on the monitoring sites. By networking multiple radar units in mesh configuration to monitor the weather, data blind spot can be eliminated, hence facilitating more detailed 3D observation of meteorological phenomena.
World's smallest, lightest! (as of June 2013)
COMPACT X-BAND
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Aerosol threat

AEROSOL ALERTS: AN EARLY WARNING NETWORK

Threats related to aerosol events are a growing concern. They originate as much from natural events such as sand or dust storms, volcanic eruptions, forest fires, as from anthropogenic sources such as agricultural fires, urban pollution and industrial emissions. Suspended in the air, they are able to travel very long distances and strongly affect human and economic activities on a large scale.

Forecasting these migrations is a difficult task that must take into account highly variable wind structures as well as interaction with precipitation.

As a result, ground-based remote-sensing technologies are strongly needed to complement satellite imaging and in-situ air quality control systems with real-time and more precise observation.

Two methods are known: multiband solar photometry to determine the types of particles, and lidar technology to retrieve their vertical structure. Exhibitor Cimel Electronique has made use of its long experience in both technologies to develop a new automatic observation station for early warning networks. The station will proudly be on display at Meteorological Technology World Expo 2013.

The innovative Aerosol Automatised Monitoring Station (AAMS) combines two operational instruments: a Sun Sky Lunar photometer for the most advanced determination of particle types and a compact maintenance-free micro-lidar. A common data-processing system continuously provides near real-time information to feed nowcasting models and enable the forecaster to alert authorities.

By implementing a network of AAMSs adapted to regional aerosol hazards, national met services, environmental national agencies and aviation authorities will be able to efficiently forecast the consequences of events such as volcano eruptions, sand storms and pollution crises.

STAND: 3072

FACT

Meteorological Technology World Expo 2013 will host more new product launches and more new exhibitors than ever before!

EXHIBITOR SPOTLIGHT

LIDAR SOLUTION

Leosphere designs and manufactures industrial-grade lidar products for remote and real-time measurement of atmospheric parameters such as wind velocity, turbulence and the presence of particles. It has more than 350 lidars deployed operationally all over the world.

At the Expo, Leosphere will present its latest range of dedicated ash and aerosol detection lidars, as well as its WINDCUBE 400S – a lidar system for wind-shear alerting.

"Our scanning range of lidars provides a high spatial and temporal resolution 3D wind map in real-time. It can detect and analyze complex atmospheric phenomena such as wake vortices and wind-shear in an airport environment," explains Ludovic Simonneau, head of product marketing for Leosphere. "On top of contributing to the optimization of the runway throughput, detecting these wind hazards is crucial for ensuring air traffic safety during the critical phases of aircraft take-off and landing."

Leosphere is heavily involved in the European SESAR program aimed at optimizing air traffic over the next 20 years. Different experiments at Charles de Gaulle airport have, for example, shown that Leosphere lidars (scanning and vertical profilers) are suitable for real-time study of wake vortices.

"The R-MAN 510 aerosol profiler, an operational Raman lidar super ceilometer, comes as an answer to volcanic ash threats at cruising altitudes," continues Simonneau. "It is the only automatic, networkable, compact and eye-safe instrument on the market that can unambiguously classify aerosols (heights of planetary boundary layer, detection and identification of clouds (ice, water) and aerosols (pollution, marine, dust, ash...)."

Simonneau is already looking forward to Brussels, this October: "MTWE 2013 is the perfect venue to showcase our latest lidar innovations addressing meteorological and air traffic control issues for both research and operational applications. It is a high-quality network event that attracts key players in the meteorological field who are showing great interest in our products. The last two events were very successful for us, attracting a broad spectrum of visitors, from met offices to aviation industry decision makers, helping to increase awareness of our company and product."

STAND: 3005

DIGITAL GLOBES: OUT OF THIS WORLD

First-time exhibitor Globoccess will present a new generation of digital globes with a diameter of 120-150cm, called 'OmniGlobe 48' and 'OmniGlobe 60'. These allow the real-time movement of clouds and many other kinds of animation to be displayed in a more realistic and engaging manner – essentially providing an 'astronauts view' of the earth.

As a result of a patented mirror technology and two integrated HD projectors, each with 1,980 x 1,600 pixels, the globes are able to transmit animations and real-time images onto a specially laminated acrylic sphere, which can be interactively operated by the public via separate touch screens or iPads. Topics from climate change to real-time movement of clouds, or location surveys accompanied by video recordings, are the most popular applications.

"We are pleased that with this new OmniGlobe technology, Globoccess has won an international tender issued by the European Commission for the best product," says company founder and CEO Volkmar Heimann.

Globoccess will also announce its new partnership with NOAA for its Science on a Sphere, as the sole European distributor for larger outside projection systems.

STAND: 7115

CONFERENCE SPEAKER

IN FOCUS:

DR JAVAD HASSANI

executive manager of Felix Technology

Dr Javad Hassani is the executive manager of Felix Technology. His presentation will focus on the SL300 Snow Depth Sensor and its new features.

"From what we observed during years of integrating and distributing environmental monitoring systems, there has been a serious gap between the real requirements of the end users and the solutions that have been provided to them in terms of the required application or usage, the performance and the price", explains Hassani. "With the increasing importance and viability of the environmental industry, the manufacturers of specific sensors and systems have not yet been able to follow the serious needs of the customers effectively, particularly when such needs or requirements have undergone a considerable change in regard to the change in the climate," he adds.

"Our mid- to long-term objective would be to establish our company as a source of a new brand of environmental monitoring sensors and instruments that address the specific needs of end users and integrators by providing them with partial or total solutions as needed."

Hassani concludes: "Our new Snow Depth Sensor is an example of the kind of solution we have developed to meet the specific requirements of a large number of customers around the world. In parallel with a few other manufacturers, which are manufacturing similar sensors, we have implemented an innovation in the design of our sensor that will provide better performance than competing products. The sensor was commercialized towards the end of 2012 and we have has sold 76 units to customers in Canada, Germany, France, Italy, Turkey, Korea, Iraq and the Kyrgyz Republic. The sensor is currently being evaluated with the products of some other manufacturers by the World Meteorological Organization (WMO)."

MAINSTREAM CONFERENCE

With two constant conference streams and 60+ speakers covering aviation, modeling and simulation, agriculture, shipping and marine, case studies, radar, measurement and technology, energy and thunderstorms, this year's conference in Brussels is set to be the biggest and best yet!

Both the Mainstream Conference and Breakout Conference will be located inside the exhibition hall, and will be running throughout the three days, meaning you can pick and choose which sessions you need to watch, and then spend the rest of your time circling the exhibition searching for new technologies or services.

Both conferences really are a truly International affair, including speakers from Malaysia, USA, Europe, Japan, Taiwan, Nepal, Ecuador, India, Russia, Pakistan and Kenya.

As always, the conferences will be free to attend for anyone visiting the exhibition, which is also free.

To make sure you don't miss out on this exclusive conference dedicated to the meteorological technology industry, please visit our website for a detailed conference program, and the simple registration form for your free exhibition and conference entry badge.

DAY 1

Tuesday, October 15

Radar

Moderator: Karl G Gutbrod, CEO, Meteoblue AG, Switzerland

10:30 Newly developed solid-state weather radar and phased-array weather radar technologies
Naoki Anraku, sales engineer, Toshiba Corporation, Japan

11:00 Long-range scanning Doppler lidar for wind energy resource assessment
Keith Barr, principal product design engineer, Lockheed Martin Space Systems, USA

11:30 Weather radar upgrades using RVP900 digital receiver and signal processor
Timo Lyly, product manager, Vaisala, Finland

Modeling and simulation

12:00 Using NOAA's Science On a Sphere for science education
Sara Summers, meteorologist, NOAA European manager for Science On a Sphere, National Oceanic and Atmospheric Administration, USA

12:30 The Meteorological Service of Catalonia (SMC)
Oriol Puig, director, Servei Meteorològic de Catalunya, Spain

Measurement and technology

13:00 Eliminating GHG emissions by 2050 while providing abundant energy worldwide
Tom Blees, president, The Science Council for Global Initiatives, USA

13:30 Monitoring and modeling greenhouse gases for industries and society
Prof Kuo-Ying Wang, professor/consultant, NCU/Applied Models, Taiwan

14:00 Analysis of radar data
Mat Kamaruzaman Mat Adam, meteorologist, Malaysia Meteorological Department, Malaysia

Case studies

Moderator: Tom Blees, president, The Science Council for Global Initiatives, USA

14:30 GCOS Cooperation Mechanism (GCM)
Tim Oakley, GCOS implementation manager, GCOS, Switzerland

15:00 Arctic Robotsonde – experience and results after one year of operation
Rémy Pepin, vice president, MODEM, France

15:30 Status of hydrometeorology and climatic scenario in Nepal
Sujan Subedi, meteorologist, Ministry of Science, Technology and Environment, Nepal

16:00 Modernizing the Mid-Atlantic Regional Spaceport Weather Decision Support System – readying NASA to support the International Space Station re-supply mission
Joshua Cahall, director of sales and marketing, MeteoStar, USA

DAY 2

Wednesday, October 16

Radar

10:30 Radar technology for quantitative precipitation estimate in urban areas
Simone Placidi, atmospheric radar analyst, MetaSensing, Netherlands

11:00 Recent improvements of wind Doppler lidars based on fibre technology
Dr Ludovic Thobois, scientific studies manager, Leosphere, France

11:30 Radar networking, nowcasting, and forecasting in international locations
Bill Conway, senior vice president, Weather Decision Technologies, USA

12:00 Trends in calibration within the Polarimetric WSR-88D Network
James Romines, radar systems engineer, Baron Services Inc, USA

Measurement and technology

12:30 Distribution of continuous dry days and wet days
Weng Sang Yip, assistant director, Malaysian Meteorological Department, Malaysia

13:00 Intercomparison data between conventional instrument and automatic sensor
Manuel Ricardo Carvajal Ortiz, weather network manager, Instituto Nacional de Meteorologia e Hidrologia - INAMHI, Ecuador

13:30 Radiosonde cloud and science measurements
Prof Giles Harrison, professor of atmospheric physics, University of Reading, UK

14:00 - Micro Pulse LiDAR for high-resolution real-time boundary layer height measurements: GHG and air-quality monitoring
Dr Phil DeCola, chief science officer, Sigma Space Corporation, USA

Modeling and simulation

14:30 Global weather simulation with hourly intervals: operational system validation
Dr Karl G Gutbrod, CEO, Meteoblue AG, Switzerland

15:00 HPC solutions for weather, climate and ocean sciences
Per Nyberg, director, business development, Cray Inc, USA

15:30 Flood warning and management – increasing situational awareness
Edgar Wetzel, project manager, Kisters AG, Germany

16:00 Development of direct-reception user stations over the past 25 years
Dr Stephan Recher, EO product manager - senior project manager, SCISYS Deutschland GmbH, Germany

DAY 3

Thursday, October 17

Case studies

11:00 Visualizations for complex systems – meteorological requirements and concrete examples
Ahmed Belaidi, sales manager, Exelis Visual Information Solutions, France

11:30 Capabilities of the Mount Washington Observatory
Cyrena-Marie Briedé, director of Summit Operations, Mount Washington Observatory, USA

Measurement and technology

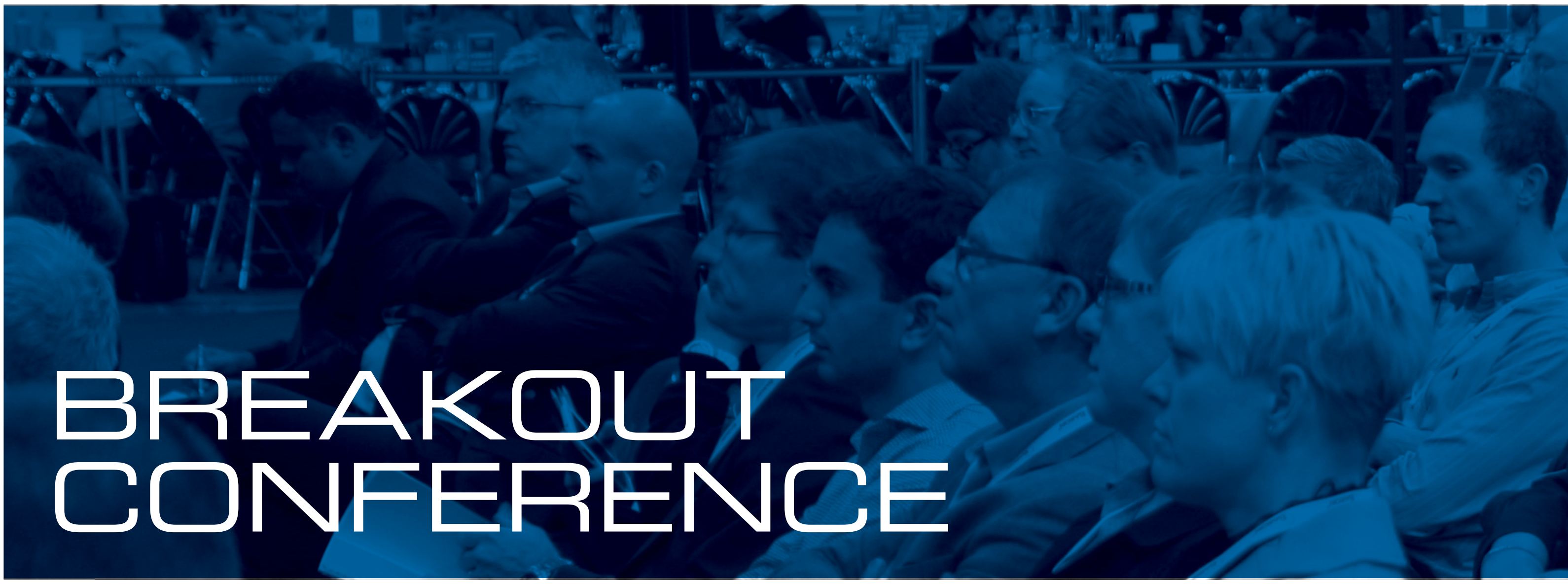
Moderator: Karl G Gutbrod, CEO, Meteoblue AG, Switzerland

12:00 An introduction to Earth's energy balance and heat fluxes
Dr Keith Wilson, atmospheric scientist, Kipp & Zonen BV, Netherlands

12:30 Pollen analyzer BAA500: influence of machine training on system performance
Prof Eberhard Schultheiss, chief researcher, Helmut Hund GmbH, Germany

13:00 Predicting landslides and flooding patterns using monitoring technology
Paul Reece, sales and marketing director, Ibexis Technologies, UK

13:30 Snow Pack Analyzer – SPA
Wolfram Sommer, CEO, Sommer GmbH, Austria



BREAKOUT CONFERENCE

DAY 1

Tuesday, October 15

Agriculture

Moderator: Nancy Vermeulen, science communicator/flight instructor, Royal Meteorological Institute of Belgium

11:00 Distributed environmental monitoring for agriculture and hazardous sites
Dr Antonio Manes, technical manager, Netsens Srl, Italy

11:30 Application of remote sensing in agriculture – Gujarat, India
Dr Vyas Pandey, professor and department head, Anand Agricultural University, India

12:00 Harnessing state-of-the-art weather monitoring and forecasting to support crop production
Dr Steve Dorling, innovations director, Weatherquest Ltd, UK

12:30 Weather pattern model for Faisalabad based on 66 years' data
Muhammad Asghar Cheema, research officer, University of Agriculture, Faisalabad, Pakistan

Aviation

Moderator: Nancy Vermeulen, science communicator/flight instructor, Royal Meteorological Institute of Belgium

13:30 Changes in meteorological services in support of international air navigation
Steven Albersheim, meteorologist, FAA, USA

14:00 Development of an unmanned aerial system (UAS) for scientific monitoring
Jon Verbeke, PhD candidate, KHBO, Belgium

14:30 Methods of low-level wind shear information communication to aviation users
Ekaterina Lemishchenko, head of department, International Aero Navigation Systems Concern, Russia

15:00 Wind hazard detection system for the TMA
Prof Mikhail Kanevskiy, Doctor of Science, professor and CEO, International Aero Navigation Systems Concern, Russia

15:30 Utilizing ATC Mode-S EHS data in the meteorological domain
Jan Sondij, MBA, senior advisor, aviation meteorology, KNMI, Netherlands

16:00 Ultra-fast wind sensors for wake-vortex hazards mitigation
Frédéric Barbaresco, senior scientist and advanced studies manager, Thales Land & Air Systems, France

DAY 2

Wednesday, October 16

Energy

11:00 Wind-farm operators
Hans-Jürgen Kirtzel, Dipl.-meteorologist, Metek GmbH, Germany

11:30 Assessing the potential of wind power in Kenya
Dr Christopher Oludhe, senior lecturer, University of Nairobi, Kenya

12:00 Impacts of weather variability on renewable energy systems
Dr Steve Dorling, innovations director, Weatherquest Ltd, UK

12:30 Measuring wind and wave conditions for Dutch offshore wind farms
Hans Verhoef, project leader Wind Energy, ECN, Netherlands

Thunderstorms

Moderator: Nelis Vets, head of the military weather forecasting center, Meteo Wing – Belgian Air Component, Belgium

13:30 A UK CAPE climatology to improve understanding of thunderstorm risk
Dr Steve Dorling, innovations director, Weatherquest Ltd, UK

14:00 Generating intelligent weather forecasts and advanced alerting with real-time observations
James Anderson, vice president, international network and business development, Earth Networks, USA

14:30 Initial results from a prototype electrostatic thunderstorm warning system
Dr Alec Bennett, senior scientist, meteorological products, Biral, UK

15:00 The effectiveness of total lightning data in severe storm prediction
James Anderson, vice president, international network and business development, Earth Networks, USA

15:30 Nowcasting strong convective events (SCE) – the Thunderstorm Thermometer
Prof Jan Parfiniewicz, main specialist, Institute of Meteorology and Water Management, Poland

DAY 3

Thursday, October 17

Aviation

Moderator: Nancy Vermeulen, science communicator/flight instructor, Royal Meteorological Institute of Belgium

11:00 Aviation industry
Hans-Jürgen Kirtzel, Dipl.-meteorologist, Metek GmbH, Germany

11:30 Automatic monitoring of cloud height and sky coverage
Marco Tadini, head of the Meteorological Department, ENAV, Italy

12:00 Schneider Electric's MetConsole ice-detection system for airport runways
James Block, chief meteorologist, Schneider Electric, Netherlands

12:30 Meteorological temperature profiler MTP-5 applications for the aviation industry
Evgeny Miller, business manager meteorology and atmospheric science, R.P.O. ATTEX, Russia

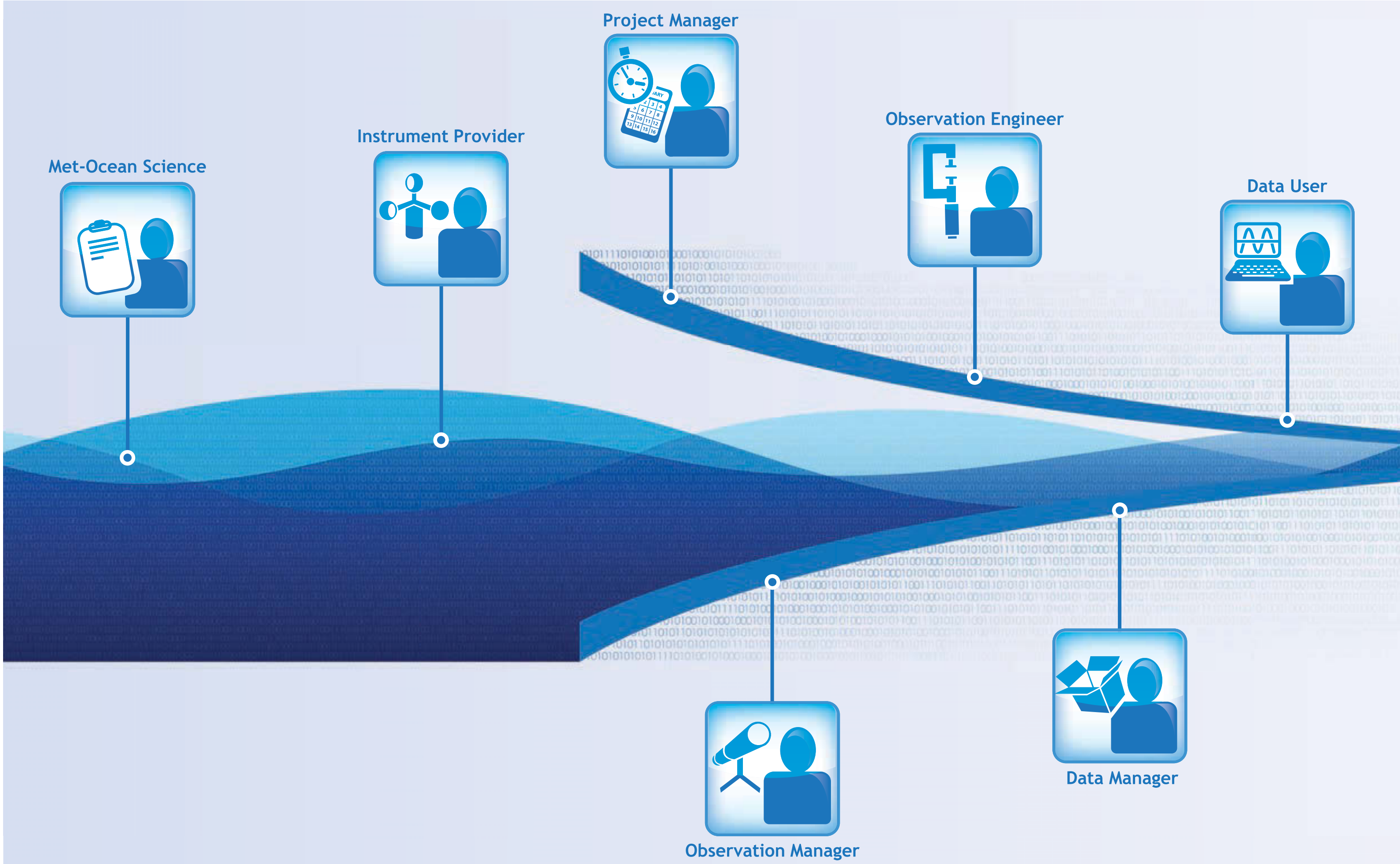
Shipping and marine

Moderator: Nancy Vermeulen, science communicator/flight instructor, Royal Meteorological Institute of Belgium

13:30 Safeport: onboard visualization of hydro-meteorological effects on ferries entering ports
Jarle Heltne, product manager, Aanderaa Data Instruments/Xylem, Norway

14:00 Voyage optimization and fuel saving using weather routing services
Bob Billett, European sales manager, Applied Weather Technology (Europe) Ltd, UK

Data Quality Systems -



Increasing demand for Met-Ocean Data

High-quality meteorological and oceanographic (met-ocean) observations are a prerequisite for rational socio-economic decision-making. In today's environment of ever changing climatic conditions the need for high quality, accurate and reliable data is increasingly vital.

Our understanding, modelling and prediction of the atmosphere-ocean climate system, the design of marine constructions (e.g.oil platforms), the optimization algorithms used for wind farm design and the prudent management of climatically influenced marine resources are all examples of enterprises that rely on comprehensive and accurate met-ocean data. Subtle changes in oceanic parameters can have a large impact on the climate dynamics which when coupled with even small inaccuracies/errors in marine installations can lead to serious consequences.

These factors underpin the importance of high-quality, accurate metocean observations to socio-economic decisions. The digitisation of met-ocean observations offers more powerful data collection and data processing capability.

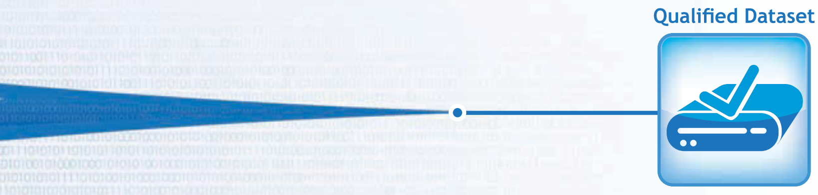
It also poses a challenge to maintain the data quality because:
i) the volume of observations being recorded is much greater and -
ii) the number of instrument types in use and the range of physical variables being measured are increasing.

These factors when combined with the increased need for data sharing among scientific communities worldwide make it more difficult to make full use of the vast amount of met-ocean observations available.

The paradox is that whilst the need for more met-ocean observations is increasing, only a fraction of all observations are ever used because the quality of the data is compromised. The combined knowledge and coordinated input from experts in different fields, often from organizations/institutes in several countries, is needed to transform the raw data from a single monitoring project to a high-quality dataset, which subsequentlycan be download and utilized by a third party.

Efficient data sharing, transportability, availability and transparency are the key challenges that need to be addressed and dealt with properly throughout the data qualification process.The "DQ Framework" is a generic software product which addresses the challenges of the process required to transform raw data to meet the specified data quality criteria ("data qualification").

Making Met-Ocean Data Useful



The "DQ Framework" enables contributors to input collectively to the data qualification process in any one or more of a set of six functions/disciplines :

1. Instrument Provider
2. Project Manager
3. Observation Manager
4. Observation Engineer
5. Data Manager
6. Data User

"DQ Framework" - Important Features :

- The original dataset, the qualified dataset and the operations/methodology used to produce the qualified dataset are held in the same file. This includes all manual corrections which are translated into code by the "DQ Framework".

- The generic flagging of data points launched by the operations (automatic or manual). This feature is used to flag suspect data, and to set the resulting flags used by the end user. This is most commonly applied as a set of soft flags (suspect values) and a set of hard flags (invalid values).

- A transportable document including all data as well as the most crucial metadata
- Outputs of the complete instrumentation package and the configuration for a specific station
- Instrument management, station management, deployment management, parameter management, operation management, and attribute management as part of the basic administration framework

- A flexible data reading capability using a DataProvider interface (generic or application specific)
- Flexible viewing features using a Qualifier view interface (generic or application specific)
- Flexible reporting features using an Export-To-Report interface (generic or application specific)
- Flexible exporting features using an Export interface (generic or application specific)

Data Quality Systems is committed to provide software and services to ensure the production of high-quality met-ocean observations (i.e. transportable datasets including metadata and qualification information)

by Steven R Albersheim

MEETING OF MINDS

Changes in services to support international air navigation

The World Area Forecast System is making significant progress to improve meteorological information for the aviation industry as industry groups converge to make things better

During 2012 and 2013, the ICAO convened three meetings that formulated a new course for the future of meteorological services. This new course will be far different than what has been the customary provision of services.

The first meeting, in September 2012, was the ICAO World Area Forecast System (WAFS) Operations Group (WAFSOPSG). At this meeting, the members representing each of the ICAO regions agreed to the implementation of the new WAFS global forecasts in grid point format for icing, turbulence, and cumulonimbus clouds. This gridded data will become operational in November 2013 and will make available digital forecasts of icing, turbulence and cumulonimbus clouds. These forecasts can then be ingested directly into flight planning systems to assist in determining the best routes for aircraft.

In November 2012, ICAO convened the 12th Air Navigation Conference (ANC). At the conference, agreements regarding *ICAO Doc 9750 4th Ed of the Global Air Navigation Plan* and *ICAO Doc 9965, Flight and Flow -Information for a Collaborative Environment (FF-ICE)* were obtained. More importantly, however, was the agreement to adopt the Aviation System Block Upgrades (ASBU) with modules B1-105 and B3-105 focused on future meteorological services. The recognition for the need to develop a roadmap for the evolution of meteorological services for the next 15 years was also a salient point of the conference.

Finally, the International Airways Volcano Watch Operations Group (IAVWOPSG) met in March of 2013. They agreed to move forward with improving the quality of the services for the provision of volcanic ash cloud information, and with the development of standards and recommended practices for the provision of space weather information.

The A340-600. Future systems will allow information to be targeted for uplink or downlink to the cockpit en route, assuming there is sufficient bandwidth (Photo: Airbus)

"Improving meteorological information is necessary to support the integration of meteorological information into ATM decision making"

The FAA Los Angeles Airport simulator

Information improvement

These three different meetings, while independent of each other, are intertwined with the future of the provision of meteorological services for aviation.

The international community has recognized that the legacy protocol of text products cannot meet the services that are needed for performance-based navigation. Additionally, the international community acknowledged that the level of service will vary among 'States', and that not all States will be in a position to adopt new provision of services – hence the importance of understanding levels of weather integration. Figure 1 (overleaf) shows what is commonly referred to as the ketchup/mustard diagram, used to illustrate the roles of responsibilities of services between the meteorological provider and air traffic management (ATM), including the airline operations center and the flight crew.

Improving meteorological information is necessary to support the integration of meteorological information into ATM decision making. Figure 2 illustrates five levels of integration ranging from zero to four. The challenge is to get to level four while recognizing that not all States and operators will require a level four service. Many users of meteorological information may not require support higher than level 2. Issues on how services will be provided have not been defined, and it will require several years of developmental work to define service standards and required procedures.

The planned implementation of the meteorological Weather Information Exchange Model (WXXM) will move away from the traditional alphanumeric code (TAC) to a digitized meta tagged data format that allows for greater flexibility to extract and use the specific element required to support a decision.

The overseeing of this effort within the ICAO rests mainly with two groups. The first, the Air Traffic Management Requirements Performance Panel (ATMRPP), is very interested in defining how weather integration is to be provided. The second group, the ICAO Meteorological

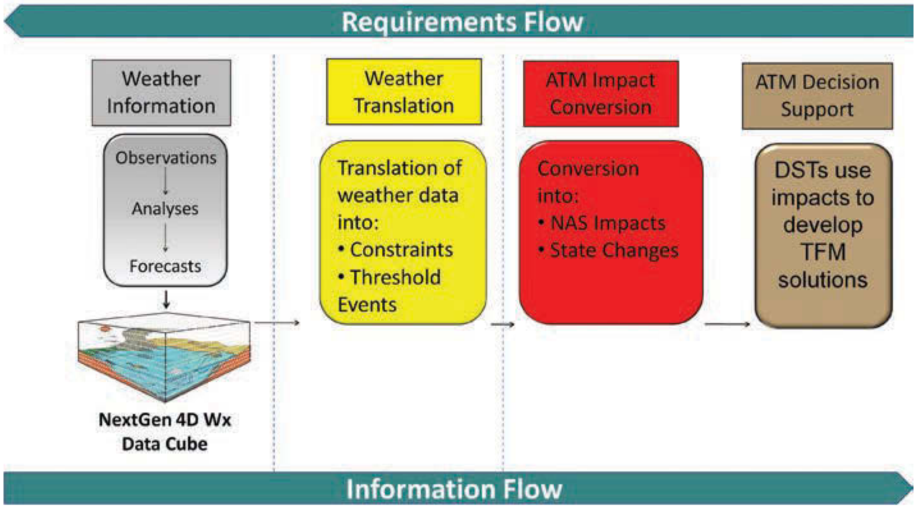


Figure 1: This diagram is commonly referred to as the ketchup/mustard diagram. It illustrates the roles and responsibilities of services between the meteorological provider and air traffic management, including airline operations center and the flight crews

Aeronautical Requirements Information Exchange Project Team (MARIE-PT), not only has the responsibility of leading the effort to advance the implementation of the ICAO WXXM model (IWXXM), but also supports the ATMRPP in defining how meteorological services in support of performance-based operations (PBO) can be provided. The first of these changes, as reflected in amendment 76 to ICAO Annex 3 (with applicability in November 2013), will be the option of States in a position to do so, to exchange METAR, TAF and the SIGMET message in extensible markup language (XML) format.

Integral to the above effort is the coordination and consultation with the World Meteorological Organization (WMO), the International Air Transport Association (IATA), and the International Federation of Airline Pilots Association (IFALPA). The latter two organizations are major stakeholders in defining the service requirements for the operational decisions, while looking at how future services will be provided with respect to the vision of ASBU.

The WAFSOPSG is beginning to better define the future required services for PBO in consultation with the IATA. As noted before, the WAFSOPSG agreed to the implementation of the new forecasts in grid point format. This change in service is evolutionary, as the international community will be looking toward the provision of defining aviation flight hazards in gridded format in addition to the legacy protocol used in chart format. While the London and Washington World Area Forecast Centers (WAFC) have been providing gridded wind and temperature data for some 20 years, this is the first time there is a change in service that supports the provision of hazardous weather in a grid point format. The first step in this effort is machine-to-machine exchange of information. Software engineers will program flight planning systems to determine the best route to maximize performance while ensuring safety of flight. Minimizing fuel consumption, which is one of the biggest contributors of cost to airline operations, will be crucial to maximizing performance of operations.

Pilot and dispatch information

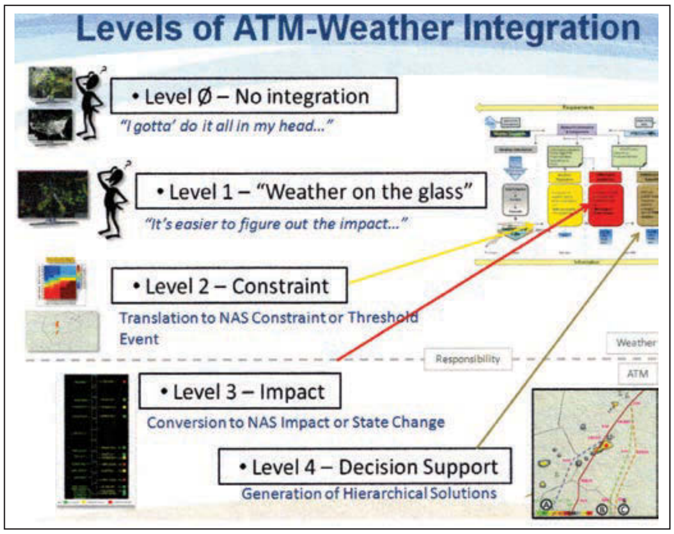
One challenging issue that has not been resolved is the visualization of the new WAFS forecasts. At the present time, the WAFCs provide Significant Weather (SIGWX) forecast charts (Figure 3) and will continue to do so for the immediate and near future.

The SIGWX charts are considered necessary for dispatchers and pilots because they provide a simplified image of the weather en route. However, these SIGWX forecasts have limitations. They are issued 17 hours in advance of their validity and are a coarse description of the anticipated weather. How does one provide real-time updates to en route aircraft with this type of service? It is not very practical. Figure 4 shows how gridded data can be visualized despite the lack of agreed international standard at this time. The advantage in the grids is that automated systems can extract specific information and display it to a dispatcher. The future will allow information to be targeted for uplink or downlink to the cockpit while en route, assuming there is sufficient bandwidth. The challenge and the future of the WAFS is how to provide more frequent updates of meteorological information, whether on a global scale or regional scale.

An additional significant change that occurred in 2012 was the agreement to move forward with the provision of space weather information. ICAO did not have a specific study group tasked to undertake this task, so it was assigned to the

> "Software engineers will program flight planning systems to determine the best route"

Figure 2: Levels of integration of meteorological information in ATM decisions and processes



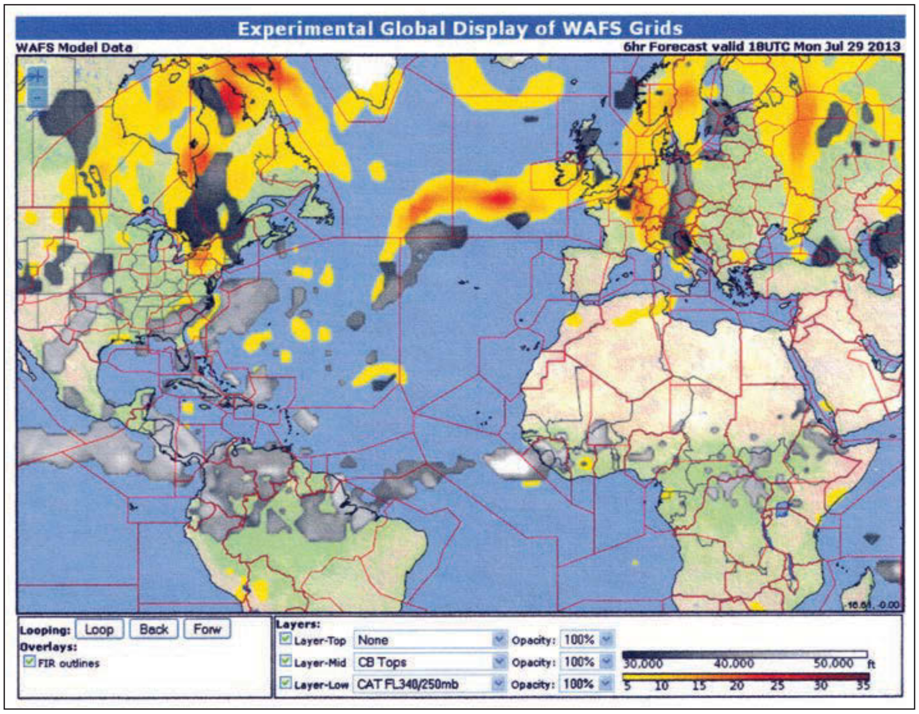


Figure 4: A visualized example of WAFS turbulence forecasts at FL 340 (shades of yellow and red), with the heights of cumulonimbus cloud tops (shades of gray)

IAVWOPSG. In 2013, a draft Concept of Operations was presented to the group to define the service requirements and the operational concept on the provision of space weather information. Space weather was first recognized at the ICAO/WMO MET divisional meeting in 2002, where examination of the issue was agreed upon. Since 2000, the number of high latitude/polar flights has significantly increased (400 flights in 2000 compared to 11,000 in 2011) as international operators recognized the importance of using polar routes to reduce flight time and fuel consumption. But operations at high latitudes incur the risk of space weather hazards, which include a disruption of communications and detrimental effects on the performance of navigation systems.

Volcanic ash

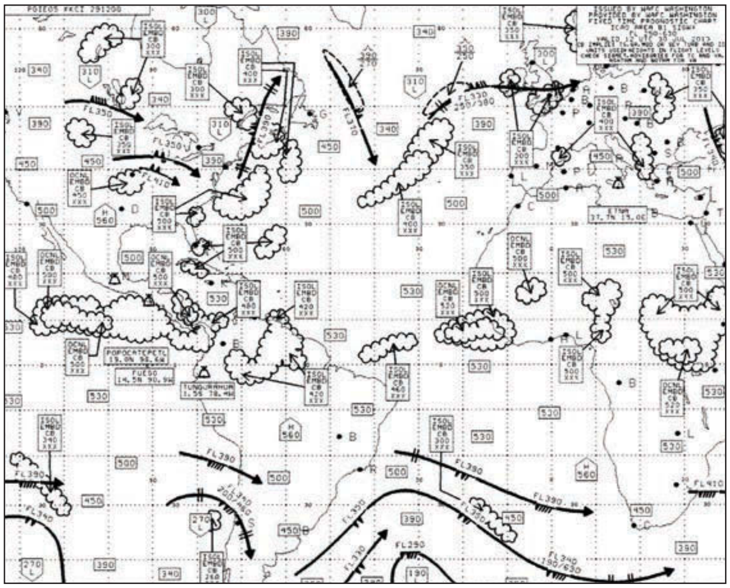
While the recognition of space weather is of great importance, not to be forgotten is the progress that has been made with regard to volcanic ash. Two very significant actions occurred in 2012. The first action was the adoption of *ICAO Doc 9974 Flight Safety and Volcanic Ash (First Edition – 2012)* and the agreement on contingency plans.

ICAO Doc 9974 lays the foundation or the ownership of risk for volcanic ash, and the contingency plans provide a configuration control of how services are provided. The second action was the work with the WMO and the experts in forecasting volcanic ash clouds to develop best practices to further understand variations in global transport and dispersion modeling. The principal purpose is to harmonize the inconsistent information that is provided not only between the Volcanic Ash Advisory Centers but also the Meteorological Watch Offices, and to move forward with collaborative decision making where applicable.

In summary, 2012 was a major milestone for meteorological services in support of aviation. Existing protocols in the provision of meteorological services are to change in accordance with the outcome of the 12th ANC and an agreement to develop a roadmap for meteorological services. Part of that roadmap is the recognition that meteorological information needs to be integrated into automated flight planning systems and decision-support tools. The WAFCs, which currently provide digital data for wind and temperature, will now embark on providing gridded data for en route hazards of icing, turbulence, and cumulonimbus clouds on a global scale. How the WAFCs will provide future services with finer scales of information is to be determined, as is their relationship in supporting States in the provision of meteorological information for the airspace they control, and the States' obligation to meet Annex 3 requirements for a flight document folder. Then, as part of the ASBUs, the international community has recognized the importance for the provision of space weather with the planned implementation of the establishment of global centers.

Finally, improvements are on the horizon for provision of volcanic ash cloud information. These, and other matters, will be discussed at the ICAO/WMO Meteorological Divisional Meeting in July 2014 in Montreal; it will define the meteorological services for the next decade based on the guidance from the 12th ANC. ∎

Figure 3: WAFS SIGWX forecast chart



Steven R Albersheim is senior meteorologist international program leader in the FAA NEXTGEN Aviation Weather Division

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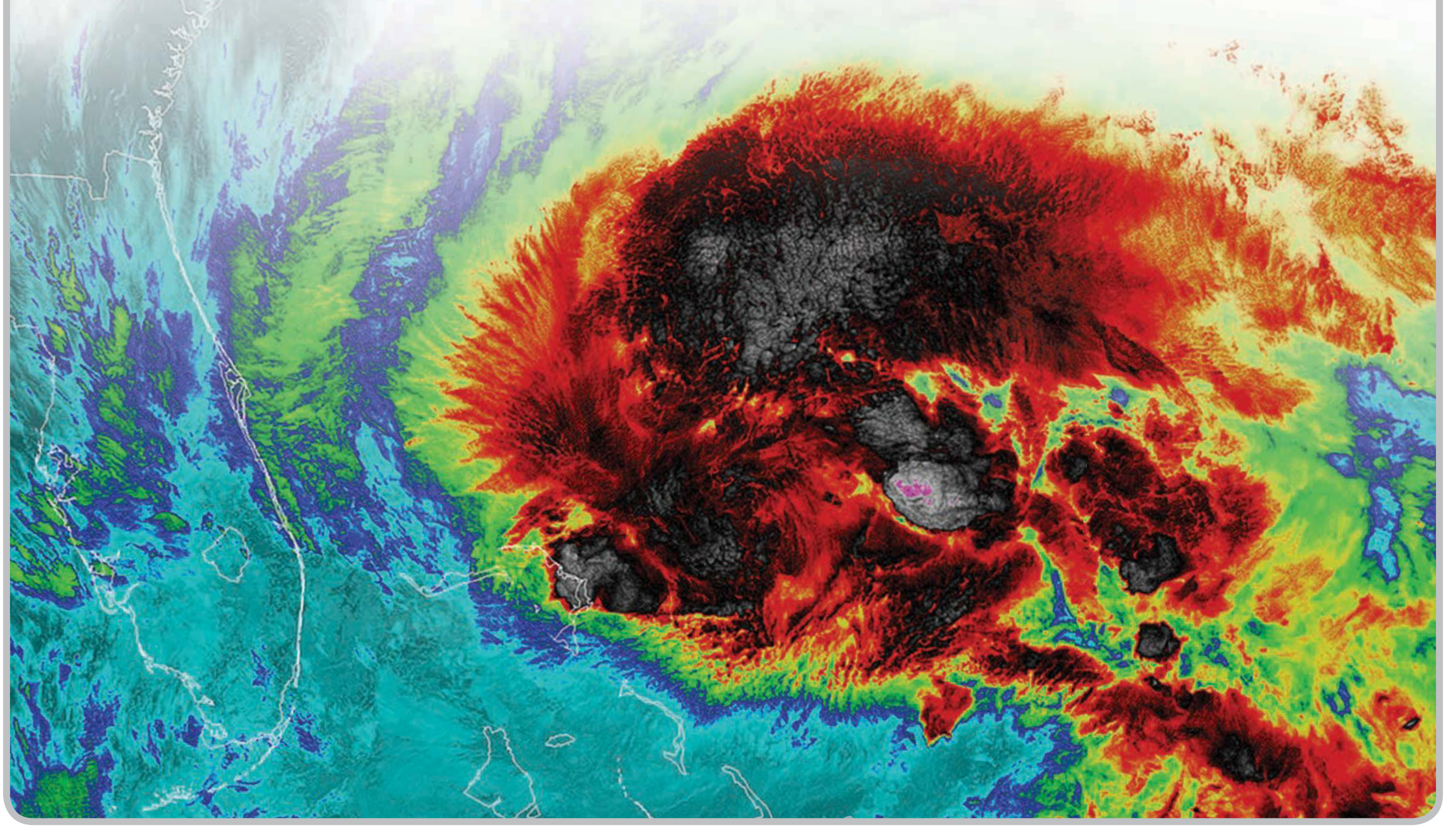

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Customer Success Is Our Mission

by Giles Harrison, Keri Nicoll, Graeme Marlton & Paul Williams

MOON'S A BALLOON

Balloon-borne measurements for Earth weather and space weather

Radiosondes are under-exploited as atmospheric science platforms, but new technologies can expand the information gathered


Photo: NOAA

Radiosondes are on the up. Using lightweight, inexpensive, low-power, disposable sensing techniques, meteorological radiosondes can now provide cloud and space science measurements well beyond the traditional thermodynamic parameters.

Balloon-carried instruments and sensors have a long and distinguished history in atmospheric science. From the early manned ascents of the Montgolfier brothers and later pioneering aeronauts in the 19th century, key discoveries on the structure and behavior of the atmosphere have emerged through balloon exploration technologies.

Modern meteorological radiosondes are launched many times daily in a coordinated way globally, but other than the few used to measure ozone, hardly any measure anything more than the traditional meteorological quantities of temperature, pressure and humidity. As miniature sensing packages they provide the basic infrastructure – power, telemetry and position information – for a wide range of other important atmospheric measurements. These sensing opportunities come at a greatly reduced cost compared with aircraft platforms, particularly as the launch and receiving equipment is already available at very many sites worldwide.

New low-cost sensing technologies can greatly improve the range of meteorological measurements obtained by standard radiosondes. For example, at the Meteorology Department of the University of Reading, advanced sensors are now in routine use to detect clouds optically and to identify turbulent regions in the atmosphere, which are potentially dangerous to aircraft. The optical and motion-sensing technology adds little to the cost of the radiosonde, which in many cases is being launched anyway, but greatly enhances the information obtained. These research-led methods already provide improved identification of cloud over the traditional thermodynamic measurements, together with directly sensed information on vigorous convection and clear-air turbulence not otherwise available.

Hazardous conditions

Radiosondes are by their nature automatic devices, so are ideally suited for use in hazardous situations. This has long been recognized (see Figure 1 overleaf for an example of radiosonde measurements safely monitoring the radioactive debris cloud from a nuclear bomb) but it is still surprisingly little exploited.

The European flight disruption due to the Eyjafjallajökull and Grimsvötn volcanoes in 2010 and 2011 proved just how

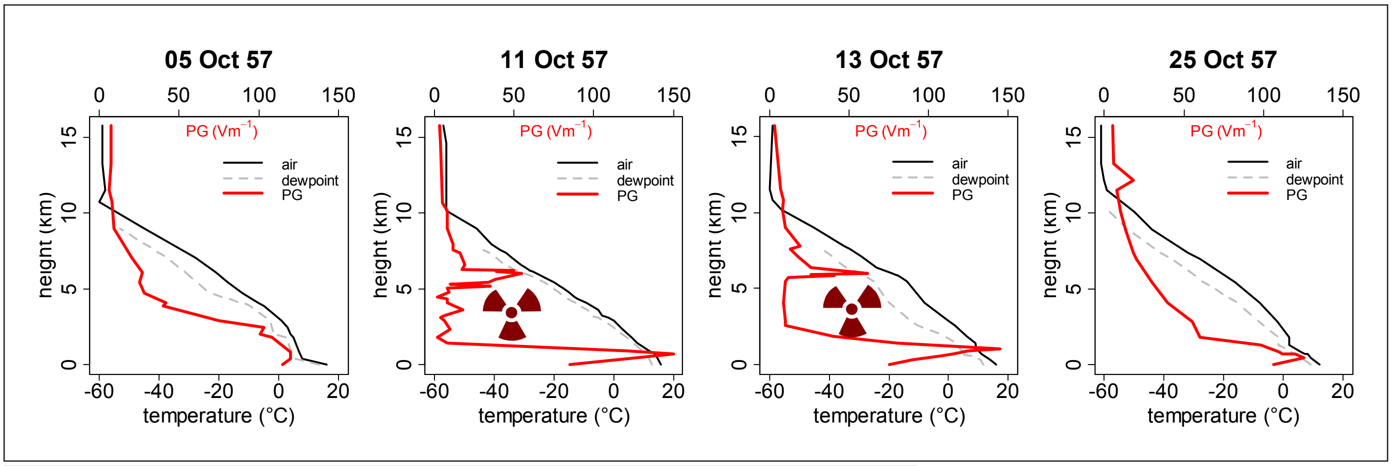


Figure 1: Sequence of radiosonde measurements through radioactive clouds over Belgium, during nuclear bomb testing in 1957. The radioactive plume region between 2km and 6km aloft is marked on October 11 and 13, as identified by potential gradient measurements (PG, red line), an atmospheric electrical parameter highly sensitive to radioactivity. The black and gray lines show the air and dewpoint temperatures respectively

useful the radiosonde platform could be in hazardous conditions, through balloon soundings providing some of the first ash concentration measurements made aloft during the 2010 flight ban crisis. (Self-charging of the Eyjafjallajökull volcanic ash plume, Environ Res Lett 5 024004, 2010.)

Cloud is conventionally inferred from radiosonde relative humidity (RH) measurements. Although such thermodynamic measurements have improved greatly in recent decades, the slow time response of the RH sensors can be a problem, particularly at low temperatures. A new disposable optical sensor developed at the University of Reading enables accurate determination of cloud layers from measurement of solar radiation. The constant movement of the radiosonde generates high variability in clear air conditions (where the position of the solar sensor with respect to the sun is important), but low variability beneath and inside cloud (where the radiation is diffuse and isotropic, hence the sensor becomes insensitive to changes in direction). This can be seen from Figure 2, which shows a radiosonde flight through a layer of stratocumulus cloud. Beneath and inside the cloud, the solar radiation is low (Figure 2b), with small variability. As the sensor exits the cloud at 1.75km, the solar radiation and variability increase as the sensor enters clear air above. Such an optical approach may identify thin clouds otherwise missed, through its improved high-resolution measurements of cloud boundaries compared with relative humidity measurements alone.

Balloon sensors

A standard radiosonde cannot measure turbulence, although its meteorological data can be used to infer regions of the atmosphere where the air is unstable and could be turbulent. Instead, two disposable sensors newly developed at the University of Reading are being used to measure the movement of radiosonde packages and to directly determine the strength of any turbulence.

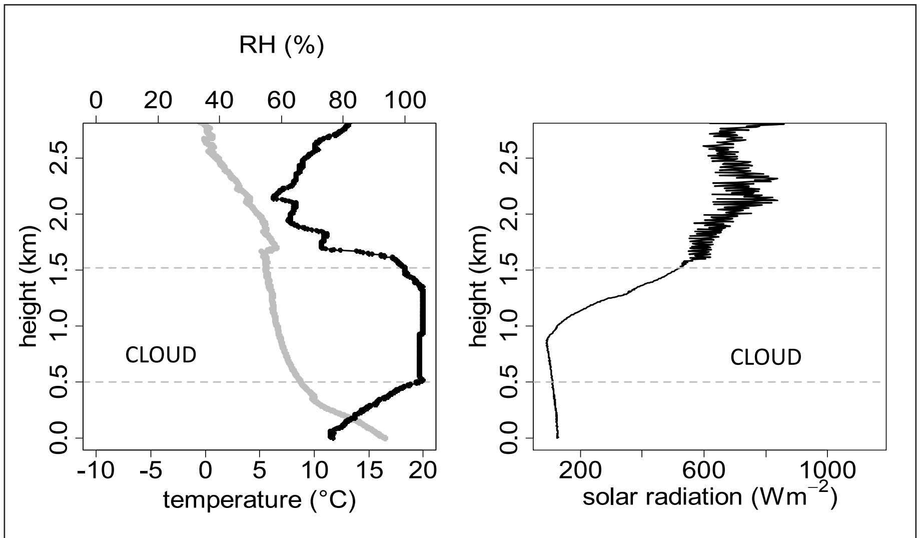


Figure 2: Measurement of solar radiation through a stratocumulus cloud, from a radiosonde flight from the University of Reading. (a) Standard meteorological measurements of temperature (gray) and relative humidity (RH, black); (b) solar radiation as measured by an optical solar radiation sensor developed at the University of Reading. (From: 'Balloon-borne disposable radiometer for cloud detection', *Review of Scientific Instruments 84, 025111, 2012*)

HALL EFFECT

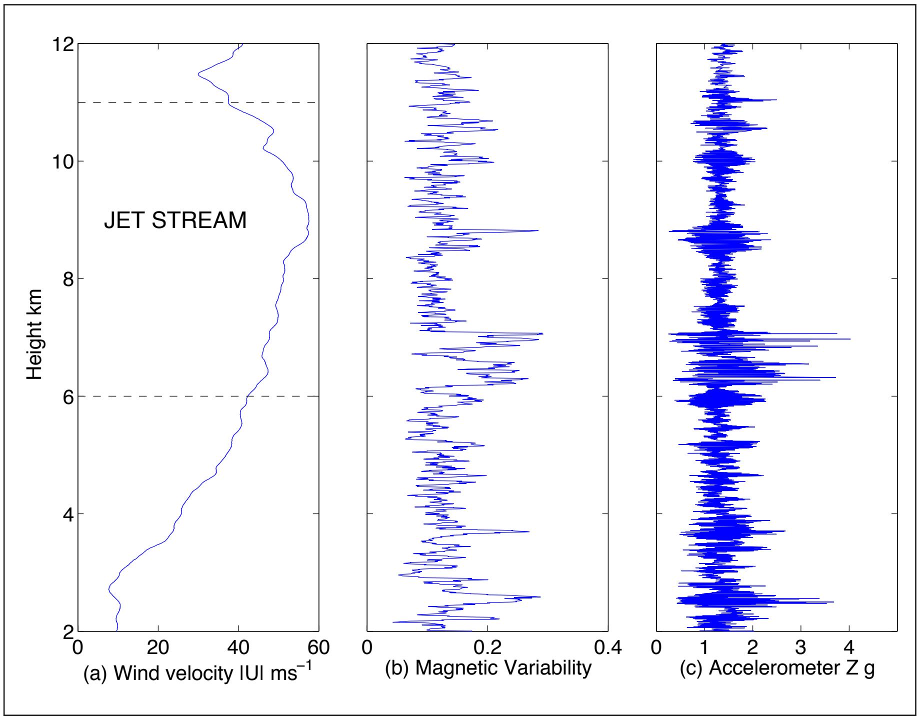
If an electric current flows through a conductor in a magnetic field, the magnetic field exerts a transverse force on the moving charge carriers, tending to push them to one side of the conductor. The Hall effect is most evident in a thin flat conductor. Using this a buildup of charge at the sides of the conductors will balance the magnetic influence, producing a voltage between the two sides of the conductor. This measurable transverse voltage is called the Hall effect after the man who discovered it in 1879: E H Hall.

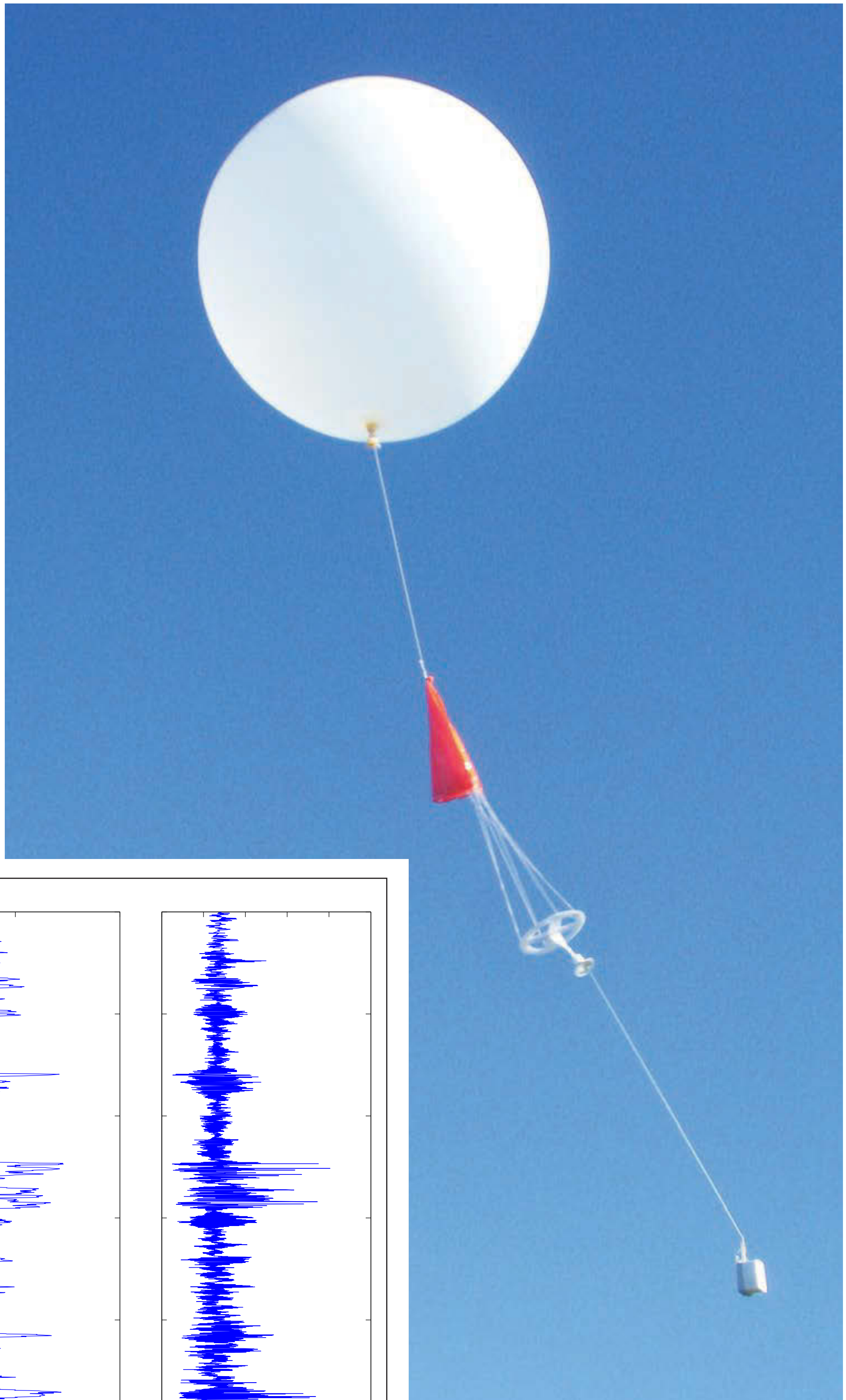
The first sensor uses the Hall effect to measure the orientation of the balloon package in relation to the Earth's magnetic field (see *In situ* atmospheric measurements using the terrestrial magnetic field – a compass for a radiosonde, *Journal of Atmospheric and Oceanic Technology, 23, 517-523*). The second sensor uses an accelerometer to measure the 3D acceleration experienced by the balloon package. Figure 3 shows that the magnetic sensor and the accelerometer both detect turbulent air at the lower boundary of a jet stream. The two sensors, combined with a solar radiation sensor, enable clear-air turbulence to be distinguished from in-cloud turbulence. Ascents such as these are providing information vital to improving our understanding of atmospheric turbulence, predicted to become more intense as the climate changes ('Intensification of winter transatlantic aviation turbulence in response to climate change', *Nature Climate Change*, 3(7), 644-648).

Space weather

Beyond aircraft protection, space weather is increasingly recognized as a hazard to

Figure 3: Radiosonde ascent encountering a jet stream around 9km. (a) Horizontal wind velocity as measured by GPS location, together with measurements from (b) the Hall effect sensor (relative units) and (c) the acceleration sensor, which both detect a region of turbulence at the bottom edge of the jet





Nearly all routine radiosonde launches occur 45 minutes before the official observation time of 00:00 UTC and 12:00 UTC

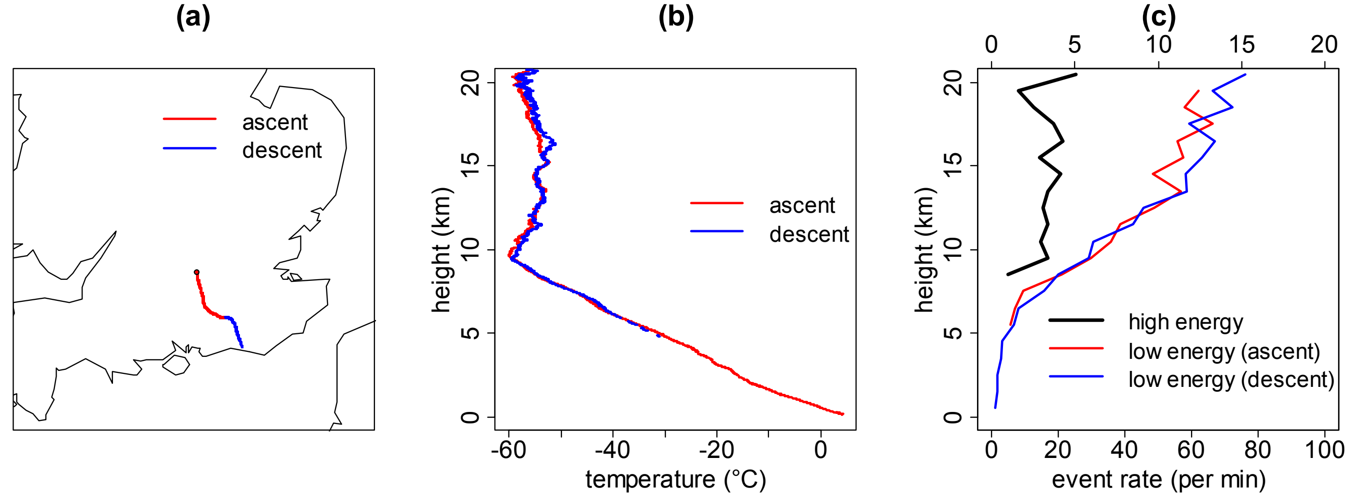


Figure 4: Space weather measurements of high and low energy particle event rate made during a radiosonde flight from the University of Reading. The standard meteorological data – (a) trajectory and (b) temperature – is unaffected by the particle sensor (c)

society's technological systems, and consequently the effects of energetic particles on the upper atmosphere – with a potential implication for weather and climate – present a new area in which scientific knowledge needs to be developed and intensive monitoring may ultimately become beneficial.

Airborne cosmic ray monitoring exploiting routine meteorological balloons now presents a cost-effective method for detecting high-energy particles entering the lower atmosphere.

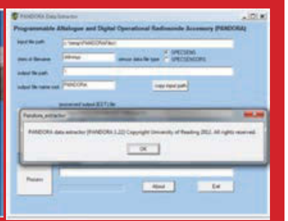
As more national meteorological services become responsible for space weather forecasting, the synergy with their existing use of radiosondes in conventional weather forecasting seems likely to be adopted more widely. Figure 4 shows an example of space weather measurements of high-energy particles made using a standard radiosonde to provide power and telemetry. The meteorological data is still obtained in the standard manner, and the standard GPS information is also useful for further interpretation of the space weather sensors.

RETRIEVING THE SCIENCE MEASUREMENTS

The University of Reading radiosonde measurement system uses a simple and rapid method of attachment to the host radiosonde, employing a single box containing the interfacing electronics and, in many cases, the necessary sensors as well.

This device, the Programmable Analog and Digital Operational Radiosonde Accessory (Pandora) has already been tested at a UK Met Office radiosonde launch site, and no detrimental effects were found on the radiosonde's standard meteorological data. (Results reported in 'Programmable data acquisition system for research measurements from meteorological radiosondes', *Review of Scientific Instruments* 83, 036106, 2012.)

Software has also been developed to enable the sensor data telemetered to be easily extracted with the meteorological data for further processing.



System deployment

One reason why the radiosonde has seen so little use as a workhorse for measurements of air pollution, cloud properties, aircraft hazards and space weather may be a perceived difficulty in obtaining and deploying the additional sensors needed, or even worries about a possible threat to the quality of the standard meteorological measurements.

At the University of Reading the radiosonde science program initially concentrated on the sensing technologies – for example the measurements of ash and dust aloft – but it has also pioneered a plug-and-play approach to allow existing radiosonde flights to be used simply with additional sensor packages (see *Retrieving the Science Measurements*, above). This straightforward methodology, combined with data-retrieval software, is particularly well suited to the occasional use of such equipment by inexperienced staff, but has also been in long-term use as part of a research measurement program. This adjacent sensor approach has been thoroughly compared against standard radiosondes carrying no extra sensors, and the published results show no appreciable difference between this and meteorological data from the enhanced radiosonde.

In summary, new sensors integrated simply with existing radiosonde systems open up a wide range of atmospheric monitoring and measurement applications. ∎

The authors, Giles Harrison, Keri Nicoll, Graeme Marlton and Paul Williams, are all with the Department of Meteorology, University of Reading, UK. See http://environmentalresearchweb.org/cws/article/opinion/50353

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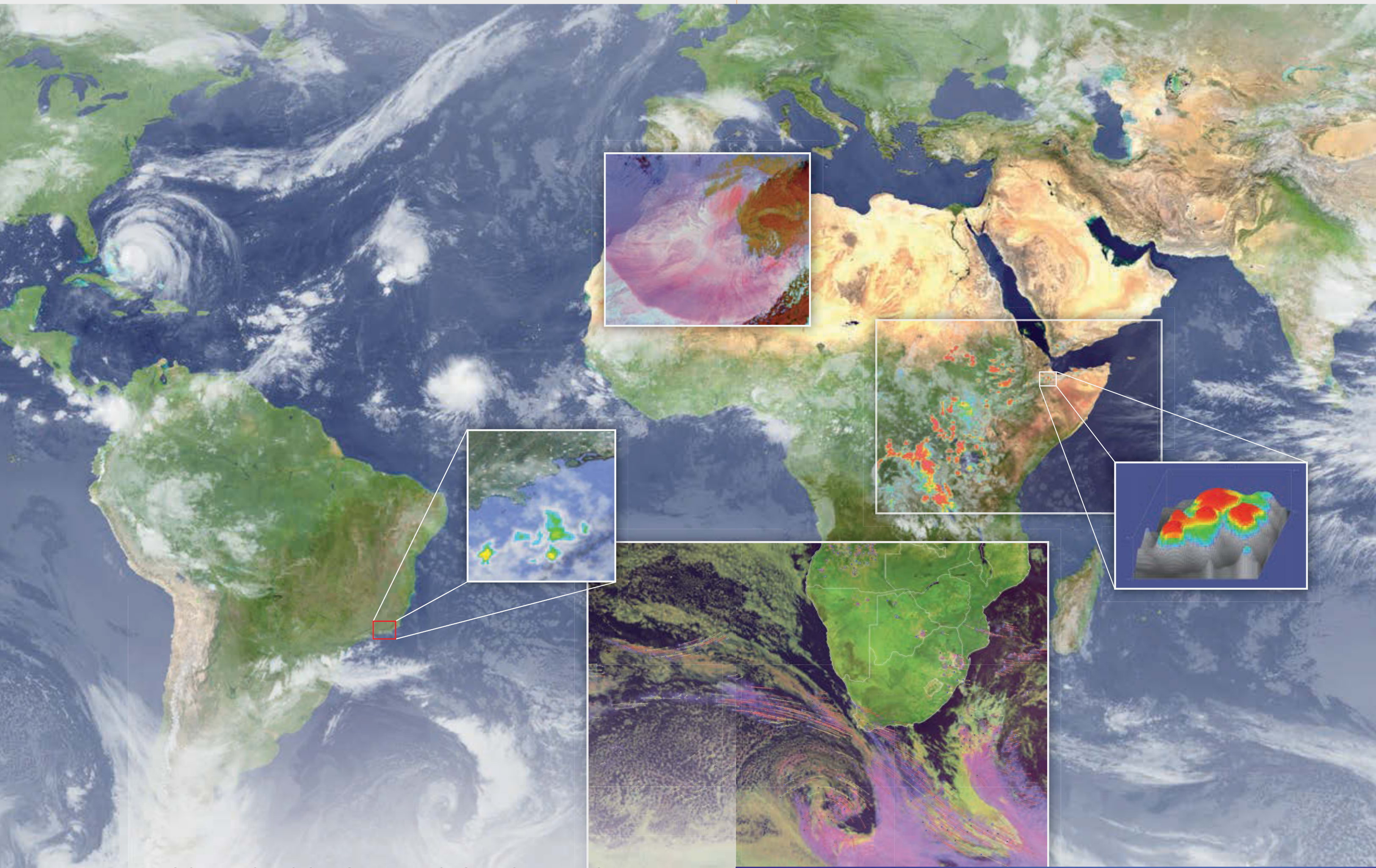

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by Daryl O'Dowd

SOW THE SEEDS

Cloud seeding – can weather modification offset global climate issues?

Science can put weather theory into action around the globe by controlling the weather – with the prediction of precipitation then being a forgone conclusion

Using science to manage the Earth's meteorological environment has long been a goal of peoples, businesses and nations. The social, commercial and indeed military advantages of such weather control are enormous. While the possibility of deflecting hurricanes and tornados or stopping lightning still remains mostly theoretical, other precipitation-focused weather modification initiatives are being conducted around the globe with positive results.

The notion that weather could be altered stretches back two millennia to the Greek biographer Plutarch (AD 46-120), who observed that great battles were often followed by rain. Edward Powers in his 1871 treatise titled *War and the Weather* made a similar connection between rain and artillery barrages. In the 1920s, it was observed that rainfall around British factories was less on Sundays – the day the mills were closed – and was attributed to an absence of fine chimney flue dust, which acted as nuclei or seeds on which rain could form. In 1946, US laboratory and aerial field trials confirmed the effectiveness of dry ice (CO_2) and silver iodide (AgI) as nucleating agents.

UNITED NATIONS ENMOD TREATY

During the Vietnam conflict, US military forces secretly experimented with the use of cloud seeding as a tactical military tool. Project Popeye (1967 to 1972), using C-130 Hercules transport aircraft with silver iodide pyrotechnic dispensers, was a seeding program designed to cause landslides, wash out river crossings, soften road surfaces and inhibit troop movement through increased rainfall. The project – believed to have had some success – was suspended after the public became aware, and ultimately led to the 1977 UN Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD).

While 76 countries have acceded to or ratified the treaty – including the US, the UK, Russia, North Korea and China – there are some notable exceptions. France, Israel, Saudi Arabia and South Africa are still outside treaty obligations, and many countries that were signatories have yet to ratify it, including Iran and Iraq.

Precipitation formation

The mechanism of precipitation formation is critical as it determines the type of cloud seeding treatment to be applied. Clouds fall into two categories – warm topped (usually maritime) and cold topped (usually continental). In warm-cloud situations, cloud forms through condensation of atmospheric water vapor on natural hygroscopic deposition nuclei, called cloud condensation nuclei (CCN). Once condensation commences, different terminal velocities of variously sized cloud droplets result in drop collision and coalescence.

However, except in the presence of unusually large CCN as are often found in the salty air within maritime clouds, natural precipitation generally cannot arise out of this collision process alone. Growing droplets ultimately become unstable and fragment or evaporate back into smaller droplets unless they reach a diameter greater than 20µm. Seeding materials are designed to coax droplets to grow beyond this size, after which raindrop growth will occur naturally.

In cold-cloud situations, precipitation similarly doesn't arise out of the simple collision and coalescence of cloud droplets; an ice phase must be present. However, cloud droplets don't readily freeze and can remain liquid and supercooled at temperatures as low as -35°C. To trigger freezing, solid particles called ice nuclei (IN) – naturally or artificially produced – must be present. IN, unlike CCN, are considerably rarer in the atmosphere, often measuring fewer than 1 per liter. A concentration between 1 and 10 per liter is necessary for efficient precipitation formation and it is this paucity of natural IN that allows artificial cold-cloud seeding to be effective.

Seeding materials

To seed warm clouds, the seeding agent must have the size and hygroscopic surface characteristics necessary to encourage growth beyond 20µm. Seeding materials include large solid salt particles (NaCl) as well as pyrotechnically produced hygroscopic gas precipitates. Even water drops can be used at cloud top as long as they fall through

Right: C-band radar and C-340 seeding aircraft in Texas (Picture: Daryl O'Dowd)

Below right: Ground-based AgI generator. The AgI is dissolved in acetone and combusted in a propane burner (Picture: Snowy Hydro)

AERIAL DELIVERY

After World War II, fighter aircraft were commonly available, and in 1948 a Lockheed P-38 Lightning was one of the first to be used in commercial cloud seeding over the Sierra Nevada mountains of California. Since then, a wide range of aircraft has been used, from modified crop dusters used to distribute milled salt to Lear executive jets with belly-mounted pyrotechnic ejectors. Helicopters have been used in Japan, but sensitivity to icing and high operating costs make them unattractive seeding platforms. Light UAVs have been used in the Maldives, but airspace and line-of-sight restrictions, together with limited loiter time and cargo capacity, make them poor choices.

the cloud, encouraging collision and therefore coalescence.

There are two approaches to seeding cold clouds. One is to use pyrotechnically generated silver iodide, applying it in either the inflow regions below clouds or directly into growing cumuliform towers. The silver iodide forms hexagonal crystals that mimic the shape and size of natural ice crystals and trigger freezing.

During combustion, 10^{11} to 10^{14} crystals are produced per gram of seeding agent. The second approach is to induce homogeneous nucleation – forcing the natural cloud water droplets to freeze – by adding a chilling agent such as dry ice pellets or liquid nitrogen, or by releasing propane as a fine non-combusted vaporizing mist. In either approach, activated IN will then continue to grow through vapor deposition, aggregation through ice particle collision and liquid water riming, and finally fall as snow. Where the goal is hail suppression, an increase in the number of hail embryos is beneficial, the competition for cloud water decreasing the individual sizes of the seeded hailstones.

Seeding delivery systems

Commercial cloud seeding generally is undertaken from either an aerial platform or using strategically placed ground-based systems. Aircraft – when under radar control – offer the advantage of being able to place seeding material exactly where needed, but face limitations when seeding areas that conflict with busy airspace demands or when operations must be carried out at night or in high terrain. In 2005, a cloud seeding aircraft in Argentina was lost during a night hail suppression mission in the lee of the Andes and another seeding aircraft crashed into a rice paddy in India. Aircraft costs are also high and finding qualified pilots to fly into bad weather – the opposite reflex for most pilots – can be challenging.

Aircraft deliver seeding agent in a number of ways depending on the precipitation formation mechanism in play. Solid salt particles or dry ice chips can be ejected from the aircraft through automated auger or conveyer systems, while pyrotechnic devices – flares – are either instantly ejected downwards from the aircraft belly or continuously burn in place in racks behind the ailerons. Large pressurized flasks (Carley burners) containing silver iodide dissolved in an acetone solution can also be carried under the wings and selectively ignited from the cockpit at cloud base.

Ground systems offer design simplicity and low cost, and often consist of only a tank of seeding agent and a second tank of fuel. The seeding agent is usually silver iodide dissolved in an acetone solution much like the flask system used on aircraft, although pyrotechnics (flare trees) and chilling agents are also used, particularly in conjunction with snowpack enhancement. Ground systems cannot target specific clouds and must be operated well in advance of a weather event to ensure sufficient seeding material collects in the boundary layer.

A third type of seeding system – mobile ground-based rockets or cannon shells – has been and is being used in isolated areas where frangible shell casings don't pose a threat to people on the ground. Such systems have commonly been used by governments in second world communist countries, including China and the former Soviet Union and its satellites.

Recently, there has also been a curious revival of a fourth type of seeding system – the unproven 'hail cannon' – with huge upwards facing cones that boom out

SIDE EFFECTS

While adding a seeding agent can optimize cloud precipitation processes, accidental or deliberate over-seeding can result in reduced precipitation. As has been observed in the polluted air downwind of large industrial complexes, clouds can become sterilized, with too many nuclei attempting to grow in an environment containing far too many fine cloud droplets. This may be desirable if a region has had excess precipitation, or if additional rain or snowfall could interfere with large-scale construction or similar outdoor events. Precipitation was actively suppressed for the 2008 Olympic Games in Beijing.

> "Today, more than 40 rain and snow enhancement, and hail suppression, projects are in operation around the world"

tremendous noise and a column of roiling hot air in the hope of disrupting hail in the making (see *MTI* May 2011, p23). In the heyday of hail suppression in Europe at the end of the 19th century, more than 10,000 of these arcane devices were distributed around vineyards. Neither the physical processes involved nor statistics attesting to effectiveness have been properly detailed, although hundreds of these units are sold annually to farmers with high-value crops.

Does it work?

In the 1950s, when weather modification first became commercialized, 'rainmaking' was very much an art and success claims were wildly unrealistic and often unverifiable. With the onset of sensible validation schemes involving randomized seeding of adjacent areas or adjacent clouds, and the use of high-performance aircraft, laboratory-tested seeding and tracing agents, and automated TITAN radar nowcasting (see *MTI* May 2011 pp20-22) results have became both realistic and repeatable. Today, a 13-18% increase in rainfall and a 20% increase in snowfall are routinely achieved.

Hail suppression estimates are more challenging to quantify, as they often rely on historical – and commercially proprietary – insurance loss records. Available data suggests that a 42% reduction in hail loss has been achieved in Europe, and the Weather Modification Association – the agency that certifies members in the conduct of operations – claims that a 27-45% reduction is possible.

Endorsement by the world's largest professional weather agencies – the World Meteorological Organization (WMO) and the American Meteorological Society (AMS) – is qualified. The WMO acknowledges the effectiveness of frontal and orographic cloud seeding as well as the use of hygroscopic seeding agents for rainfall increases, but stresses the need for continuing strategic research. The AMS cites concerns about targeting and adequate randomized research, and cautions that any program of cloud seeding to minimize drought needs to be part of a broader ongoing water management strategy. Indeed, cloud seeding doesn't create clouds, it can only alter the efficiency of the precipitation mechanisms within existing clouds.

Nonetheless, today more than 40 rain and snow enhancement, and hail suppression, projects are in operation around the world. Many have been running for decades, suggesting that while the specific scientific processes may be uncertain, the results are not. In California, of the dozen rain projects currently in place, two have been in operation for almost 50 years. In France, a widespread system to decrease hail in the vineyards of the Loire, Rhone and Bordeaux regions has been in operation since the 1950s. Other long-running hail-suppression programs are in place in northern Greece, Spain, Russia, Canada and Argentina. Australia has attempted to mitigate periodic drought using ground-based cloud seeding in the Snowy Mountains southwest of Sydney and an aerial seeding program has been conducted in Tasmania since 1964. China undertook an aggressive seeding program to control the weather during the 2008 Olympic Games, and rain-enhancement programs in Africa and the Middle East are on the rise.

With costs as low as US$0.07 per cubic meter of run-off (approximately 1/10th the cost of desalination) and benefit-to-cost ratios as high as 60:1, the commercial viability of cloud seeding – where natural conditions are rich in water vapor but low in natural nucleating agents – is unmistakable. And in a world of changing climate, may ultimately be mandatory. ∎

Daryl O'Dowd is a Canadian Meteorological and Oceanographic Society (CMOS) accredited meteorologist and is certified by the Weather Modification Association to conduct cloud seeding programs. He can be reached at odowd@weatherdyne.com

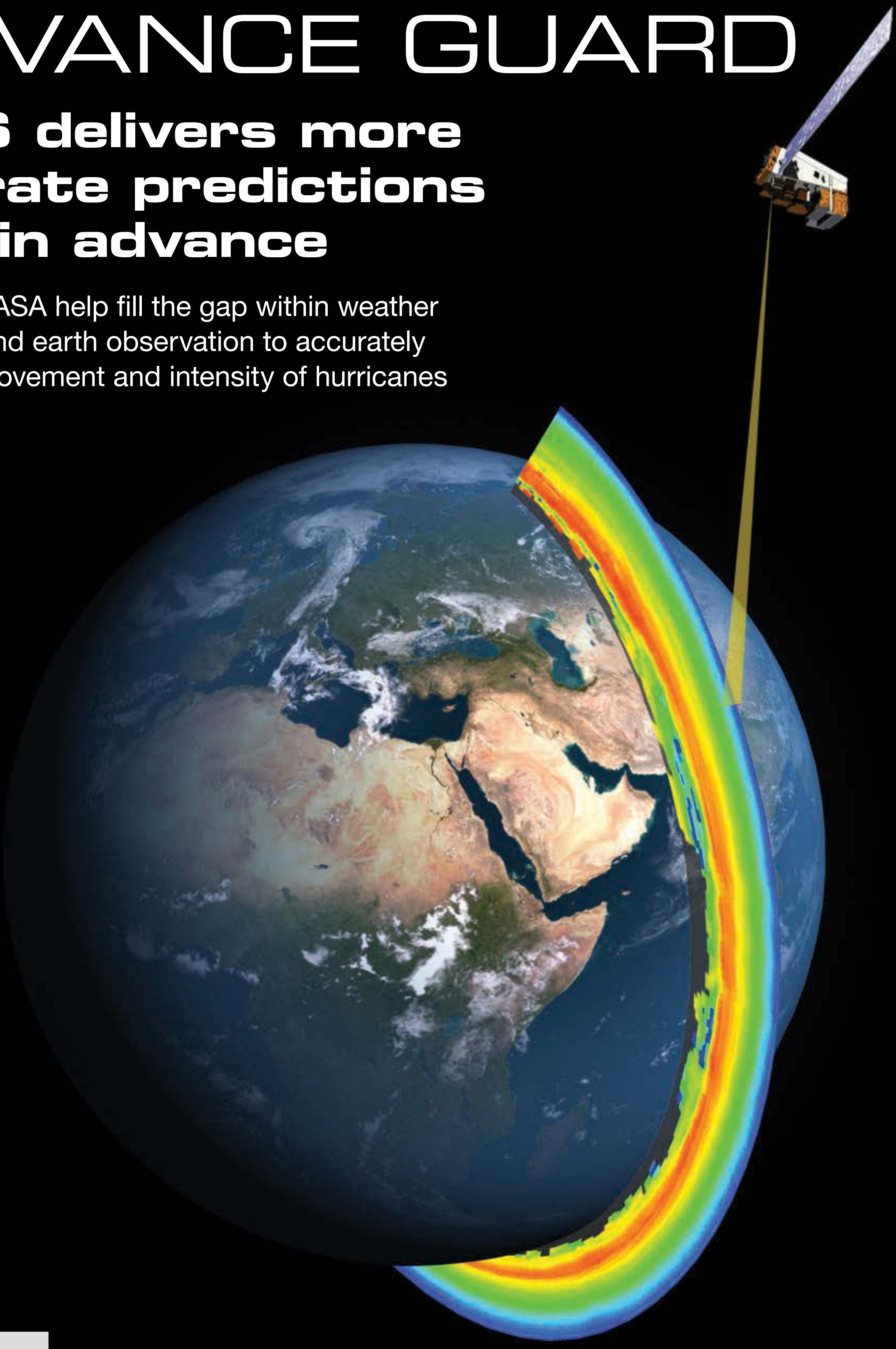
Replacing aileron AgI flares after a hail suppression mission in Alberta. Each flare burns for six minutes. Photo by Daryl O'Dowd

by Scott C. Asbury

ADVANCE GUARD

JPSS delivers more accurate predictions days in advance

NOAA and NASA help fill the gap within weather forecasting and earth observation to accurately predict the movement and intensity of hurricanes



Picture credit: NASA/NOAA

A new generation of Earth-observing satellites is making a dramatic difference in the ability of scientists to predict short and long duration weather events and long-term climate change. The Joint Polar Satellite System (JPSS) is the next generation polar-orbiting operational environmental satellite system for the USA. JPSS is a collaborative program between NOAA and its acquisition agent NASA.

In August 2011, when Hurricane Irene stormed up the US eastern seaboard, weather forecasting technology predicted Irene would directly hit New York City as a category 1 hurricane. Weather prediction models used at the time considered wind strength, distance and time, resulting in a plan to deploy millions of dollars of resources to deal with the effects of severe weather on a large metropolitan area. However, between its origination in the Caribbean and landfall, Irene weakened considerably. By the time Irene made final landfall in Brooklyn, New York, it had been downgraded to a tropical storm. While meteorologists were able to accurately predict the track of Irene five days in advance, they were not able to predict Irene's intensity accurately or in a timely manner, in part because they were working with limited data that was delivered and assimilated too slowly.

Improved forecasts

On October 28, 2011, a significant step towards improved weather forecasts occurred with the launch of the Suomi National Polar-orbiting Partnership (S-NPP) satellite. S-NPP is the first of NOAA's next generation of polar-orbiting environmental satellites. S-NPP represents major advances in meeting the most pressing needs for operational weather forecasting and climate change studies.

S-NPP showed its forecasting capabilities when Hurricane Sandy hit the east coast in November 2012. Most numerical weather prediction models showed Sandy going harmlessly out to sea, but one model was ingesting data from the satellite faster and was able to give more accurate predictions, days in advance. The convergence of several different models indicates a more reliable weather forecast. While Sandy was near Cuba, the forecasting models converged and meteorologists learned more than five days in advance that Sandy would take the infamous "left hook" into southern New Jersey. There was more time to prepare, which saved lives and made a significant difference in how resources were deployed and evacuations planned.

The advance planning for Hurricane Sandy is just one example of how polar-orbiting satellites such as S-NPP contribute vital information for national forecasts, severe weather warnings, search and rescue operations, disaster response preparations, military contingency planning and environmental monitoring.

This image of Hurricane Sandy was acquired by the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi NPP satellite around 2:11 a.m. Eastern Daylight Time (06:11 Universal Time) on October 29, 2012. Credit: NASA Earth Observatory

A rendering of the JPSS-1 spacecraft. Credit: Ball Aerospace & Technologies Corp

Data continuity

S-NPP also provides continuity of environmental data records from NOAA's Polar-orbiting Operational Environmental Satellite (POES) spacecraft – the precursor to JPSS – and also from NASA's aging Earth Observing System (EOS), a group of satellites that provide critical insights into how Earth's systems interact, including clouds, oceans, vegetation, ice and the atmosphere. Continuing uninterrupted the long-term environmental data records gathered by these satellites is critical to understanding fluctuations in Earth's climate system and provides more accurate and timely data for weather forecasting.

Ball Aerospace designed and built the S-NPP spacecraft for NASA's Goddard Space Flight Center, and was responsible for integrating the instruments and for performing satellite-level testing and launch support. Ball also designed and built one of S-NPP's instruments, the Ozone Mapping and Profiler Suite (OMPS).

Five instruments

The S-NPP spacecraft carries five instruments designed to provide operational continuity of satellite-based observations and products. These instruments trace their heritage to those on NASA's Terra, Aqua and Aura missions, on NOAA's POES spacecraft, and on the Department of Defense's Defense Meteorological Satellite Program (DMSP).

S-NPP's five instruments are the Advanced Technology Microwave Sounder (ATMS), the Cross-track Infrared Sounder (CrIS), the OMPS, the Visible Infrared Imaging Radiometer Suite (VIIRS), and Clouds and the Earth's Radiant Energy System (CERES).

CrIS and ATMS work together to measure global high-resolution profiles of temperature and moisture. These two sensors provide the majority of data used as input to Numerical Weather Prediction (NWP) models. Higher spatial, temporal and spectral resolution and more accurate sounding data from CrIS and ATMS support continuing advances in NWP models and data assimilation systems to improve short- to medium-range weather forecasts.

CrIS is a spectrometer with 1,305 spectral channels providing the ability to measure three-dimensional, high-resolution temperature profiles with greater accuracy than previous instruments. CrIS will also provide data that will help scientists understand phenomena such as El Niño and La Niña, which impact global weather patterns. NOAA is using CrIS data in its numerical weather prediction models as a test for the upcoming longer-life CrIS instrument that will fly on NOAA's JPSS spacecraft, JPSS-1.

ATMS operates in both clear and cloudy conditions, providing high spatial resolution microwave measurements of temperature and moisture. ATMS, a 22-channel passive microwave radiometer, has two more channels than previous instruments. When ATMS takes measurements inside the eye of a hurricane, it provides a clearer picture of the hurricane's warm core and the intensity of its rainfall.

VIIRS's 22 channels contribute to improved weather forecasting by measuring clouds and the nature of cloud content, which helps better predict rainfall. Along with its abilities to track long-term data on land vegetation and ocean surface features such as sea surface temperature and sea ice concentration, VIIRS tracks fires, flooding and drought as they happen. When combined with ATMS, and CrIS data, VIIRS's data on hurricanes gives scientists improved weather prediction capabilities.

For long-term climate monitoring, VIIRS continues critical data records of vegetation, clouds, aerosols, sea and land surface temperatures, the health of the biosphere, and changes in land cover. VIIRS extends the widely used data records of NASA's Moderate Resolution Imaging Spectroradiometer (MODIS), which was launched aboard NASA's Terra and Aqua spacecraft in 1999 and 2002.

VIIRS's day/night band also allows it to detect low levels of visible/near-infrared light at night to detect and discriminate between low clouds, fog, snow, ice and blowing dust/sand lit by moonlight and lightning. This represents a significant advance over previous instruments because it will provide calibrated visible observations of clouds and other phenomena at night.

The three-channel radiometer CERES measures the balance of sunlight and the heat in the Earth's system and how it changes over time, continuing the Earth radiation budget data record of other CERES instruments on Terra, Aqua and other satellites. CERES data can be used for evaluating the effects and climatic impact of natural disasters, such as volcanic eruptions and major floods and droughts.

With improved vertical resolution, OMPS takes accurate long-term measurements of the Earth's ozone layer and builds on decades of ozone observations made most recently by a predecessor instruments on NOAA's series of POES spacecraft. When combined with cloud predictions, OMPS data helps create the Ultraviolet Index, a guide to safe levels of sunlight exposure.

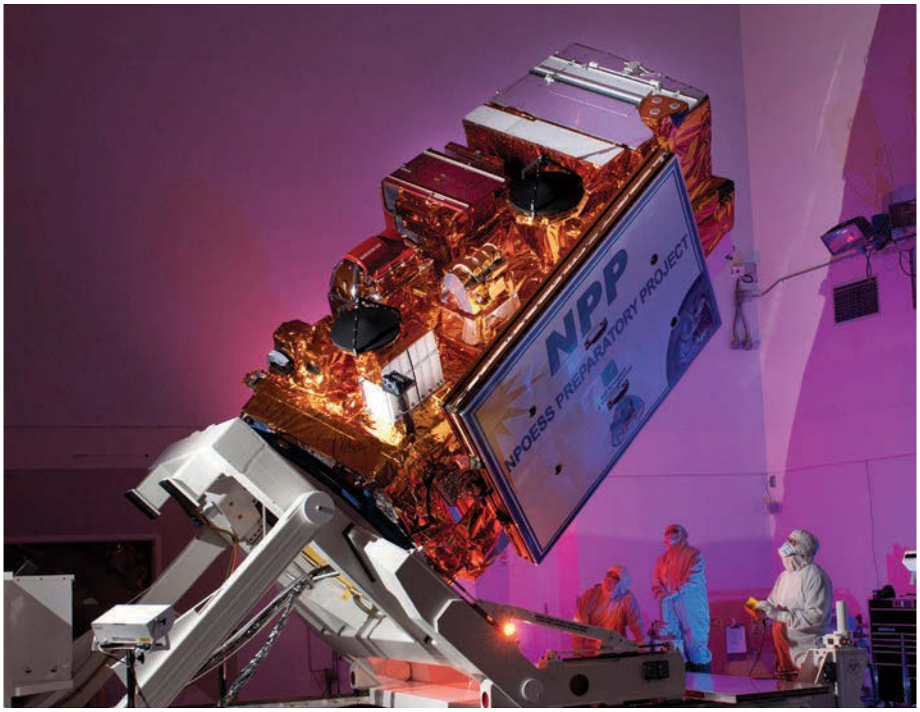
Greater detail

These S-NPP instruments offer higher spatial and spectral resolution than their predecessors, which translates to greater detail on spectra and atmospheric parameters. S-NPP orbits the Earth about 14 times each day, every 102 minutes, flying 512

This image of the continental USA at night is a composite assembled from data acquired by the S-NPP satellite in April and October 2012. The image was made possible by the satellite's day/night band of the Visible Infrared Imaging Radiometer Suite (VIIRS), which detects light in a range of wavelengths from green to near-infrared. (Picture: NASA Earth Observatory/ NOAA NGDC)

miles above the surface and always crossing the equator locally after noon. It has a five-year design life and is the eighth of 11 spacecraft built by Ball Aerospace on the Ball Configurable Platform, a core architecture designed for cost-effective remote sensing applications. The spacecraft transmits data from its five instruments to a ground station in Svalbard, Norway, and also broadcasts sensor data directly to remote users in real time. From Norway, the data is routed via communication networks to end users.

After a demanding and accelerated evaluation period, S-NPP data was in use by May 22, 2012, just seven months after launch – almost three times faster than previous missions. The data contributes to all public and private weather forecasts in the USA. Development of the software used in advanced weather models was accelerated through a partnership between NASA, NOAA and the Department of Defense, enabling the ATMS data to flow to scientists in record time.



The S-NPP spacecraft is prepared for launch at Vandenberg AFB, California (Picture: Ball Aerospace & Technologies Corp)

JPSS-1 spacecraft

S-NPP serves as the bridge between NOAA's POES and NASA's EOS satellites to the next generation JPSS spacecraft, JPSS-1, scheduled to launch in 2017. JPSS-1 will take advantage of lessons learned from S-NPP and also utilize the advances in technology that have taken place in the 10 years since the S-NPP satellite build began. JPSS-1 will fly in the same orbit with the same five instruments, which are being improved to provide the reliability needed for a seven-year mission life.

A key difference between the S-NPP and JPSS-1 spacecraft is the enhanced data delivery capability built into JPSS-1. To stream its stored mission data faster and more efficiently, JPSS-1 will have two deployable, steerable Ka-band antennas in place of the single fixed X-band antenna on S-NPP. The primary JPSS-1 Ka-band antenna will broadcast to ground stations, while the secondary or 'back-up' Ka-band antenna will broadcast data to the Tracking and Data Relay Satellite System (TDRSS), a constellation of nine satellites flying 22,300 miles above the Earth that transmit voice, television and data between spacecraft and ground stations. This JPSS-1 capability will deliver data more quickly, with no more than 80 minutes from observation to ground user. The TDRSS antenna will offer the ability to further reduce data latency should mission needs demand more rapid data delivery.

JPSS-1 will also have an updated onboard data handling system that reduces development risk and replaces the obsolete IEEE 1394 serial databus. Spacewire will be used for the high data rate transmissions required by the VIIRS and CrIS instruments. ATMS, OMPS and CERES will use a MIL-STD-1553 serial databus due to their lower data rate requirements. The JPSS-1 spacecraft and instruments are being designed for a longer mission life than S-NPP, so the part requirements and component qualification processes are necessarily more stringent. The core spacecraft architecture is the same Ball Configurable Platform 2000, which is designed to accommodate a wide variety of Earth-observing payloads that require precision pointing control, flexible high data rate throughput and downlinks and controlled re-entry.

In December 2012, the JPSS-1 spacecraft passed a delta Critical Design Review, which delineated the design differences between JPSS-1 and S-NPP and allowed JPSS-1 fabrication to begin. JPSS-1 is currently in full-scale production and will enter integration and test in early 2014.
When launched in 2017, JPSS-1 promises to deliver the most advanced satellite weather technology and further increase the efficiency and speed of data delivery. Preserving the continuity and value of long-term environmental data records, JPSS-1 will deliver life-saving information to the world's weather forecasters. ∎

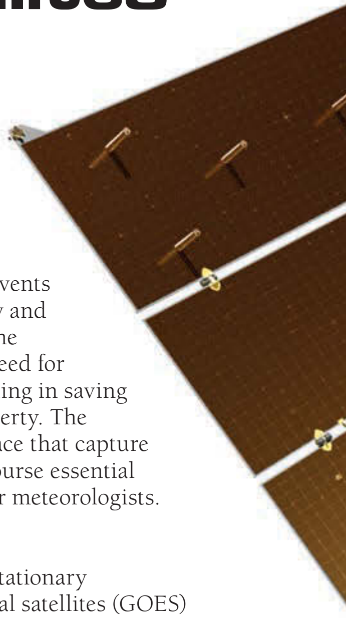
The S-NPP spacecraft is installed in its rocket housing, a United Launch Alliance Delta II-7920-10 launch vehicle. Credit: Ball Aerospace & Technologies Corp

Scott C Asbury is program management professional (PMP), senior program manager, Joint Polar Satellite System Spacecraft, Ball Aerospace & Technologies Corp by Paula Hartley

GOES COMES

New generation in geostationary operational environmental satellites

When it comes online, GOES-R will inaugurate a new era of weather satellites outfitted with a full complement of the latest instrumentation



When a series of deadly tornadoes assaulted the Oklahoma City area on May 20 and 31, 2013, television news reports and photos revealed dismaying images of catastrophic destruction.

The town of Moore had been virtually obliterated, suffering more than 20 deaths and at least US$2 billion in property damage. Persistent news coverage underscored not only the physical devastation but the emotional toll as well, with poignant scenes capturing parents embracing children who had safely evacuated from their schools, as well as surviving family members grieving inconsolably over loved ones who perished in the storm.

Around the same time, the USA's National Oceanic and Atmospheric Administration (NOAA) made its own weather-related news, releasing its 2013 Atlantic hurricane season forecast, which predicted a considerably more active hurricane season than normal averages.

NOAA's GOES-R is a series of four satellites (R, S, T and U), extending the lifetime of GOES to at least 2036. The first in the series is scheduled to launch in 2015 and will provide a major improvement in quality, quantity and timeliness of data collected over the current GOES system

The combination of destructive tornadoes and a projection of a busier hurricane season illustrates how weather events can alter life dramatically and quickly, and highlights the continuing and critical need for effective weather forecasting in saving lives and protecting property. The satellites operating in space that capture images and data are of course essential forecasting equipment for meteorologists.

GOES

For nearly 40 years, geostationary operational environmental satellites (GOES) have functioned as weather sentinels over the USA, vigilantly monitoring weather developments and solar conditions while supplying continuous imagery and data to enable forecasts as well as the identification and tracking of dangerous systems such as hurricanes and severe thunderstorms.

Since the launch of the first satellite in the series in 1975, GOES satellites have operated in fixed positions over the east and west coasts of the USA at a point approximately 22,300 miles above Earth. They maintain watch over the USA, southern Canada, the Atlantic and Pacific Oceans and Central and South America.

Operated by NOAA in partnership with NASA, GOES satellites carry various instruments that enable them to capture images, measure atmospheric temperature and moisture, and assess conditions around the spacecraft. They can also aid in search-and-rescue operations.

The satellite family

The GOES family has evolved and progressed over time. Early GOES birds were spin stabilized and viewed Earth only about 10% of the time. From April 13, 1994 – the launch of GOES-8 – to the present, GOES satellites have been three-axis stabilized, enabling them to view Earth 100% of the time. The satellites offer visual and infrared imagery to provide data for

> "In May 2013, GOES-13 went offline temporarily after apparently being struck by a micrometeoroid"

severe storm evaluation as well as information on various weather factors, such as winds, cloud cover, ocean currents, fog distribution and storm circulation. They can receive transmissions from offboard sources such as free-floating balloons, buoys and remote automatic data collection stations around the globe.

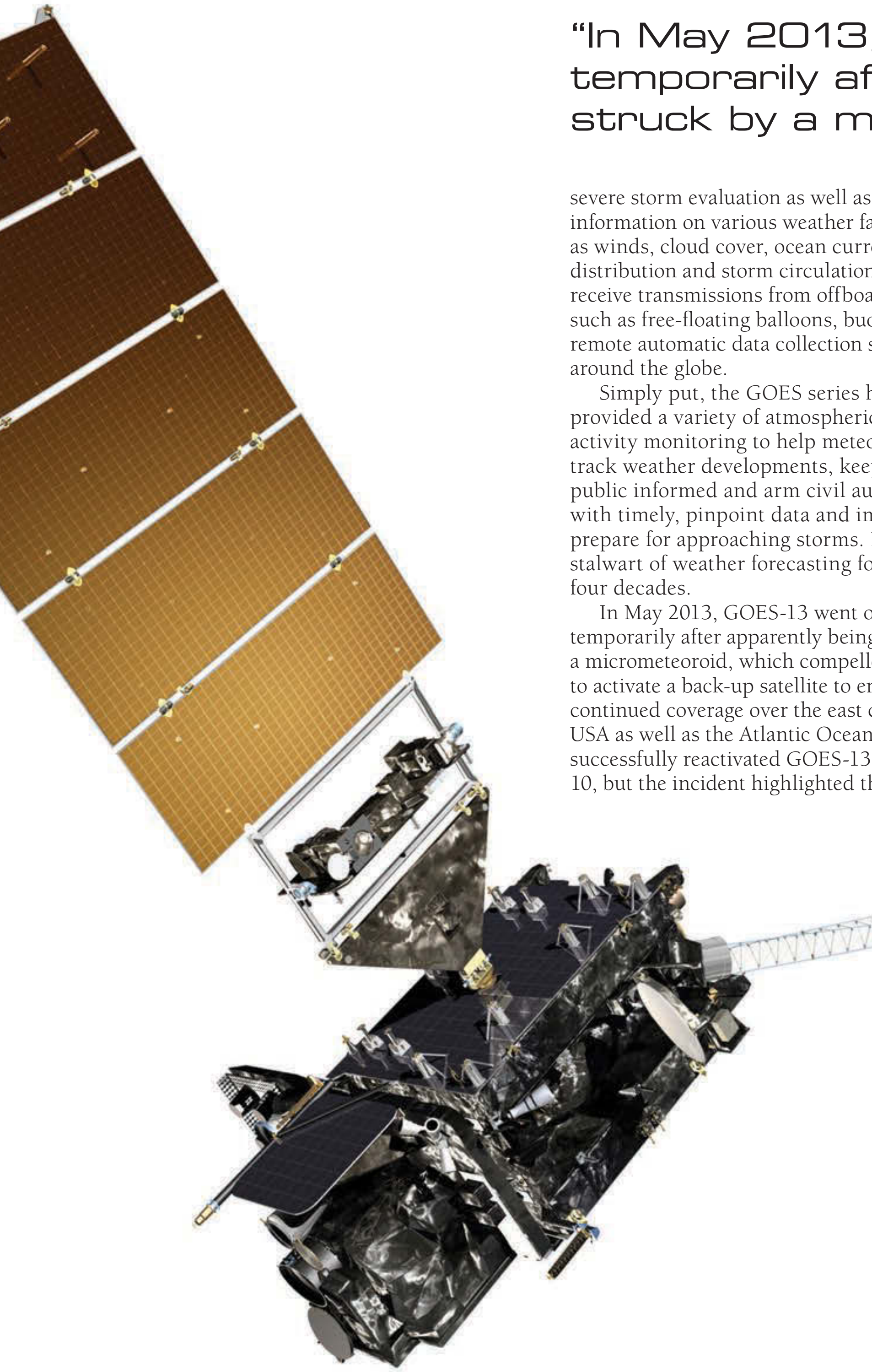
Simply put, the GOES series has provided a variety of atmospheric and solar activity monitoring to help meteorologists track weather developments, keep the public informed and arm civil authorities with timely, pinpoint data and imagery to prepare for approaching storms. It's been a stalwart of weather forecasting for nearly four decades.

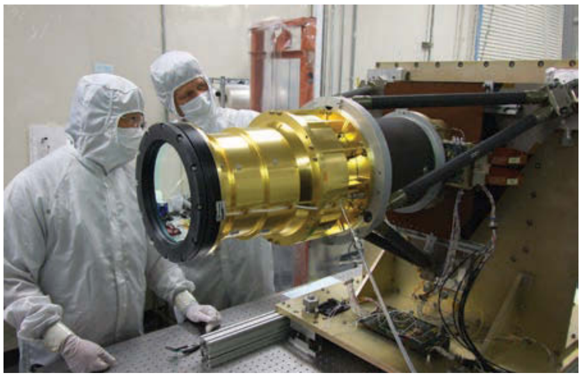
In May 2013, GOES-13 went offline temporarily after apparently being struck by a micrometeoroid, which compelled NOAA to activate a back-up satellite to ensure continued coverage over the east coast of the USA as well as the Atlantic Ocean. Officials successfully reactivated GOES-13 on June 10, but the incident highlighted the importance of the GOES satellites to daily Earth monitoring and weather forecasting.

The next generation

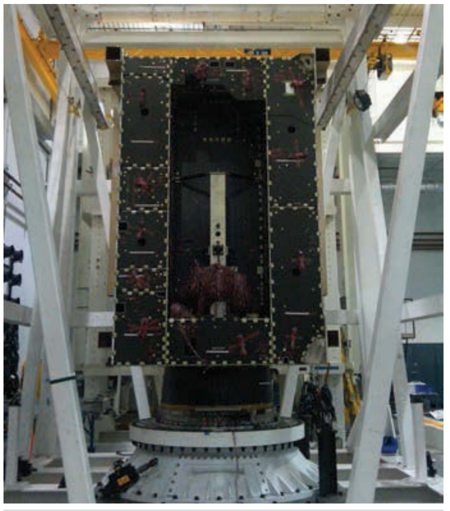
As successful and prolific as GOES has been, it is poised to ascend to the next level in performance with a new generation of satellites offering revolutionary capability. Derived from the A2100 satellite platform, GOES-R will boast advanced instrument technology such as more visible and infrared channels, four times the imaging resolution and a new lightning-detection capability.

The GOES-R spacecraft is a three-axis stabilized design with high-accuracy pointing and extremely high stability, achieved by a specially isolated Earth-pointing platform. Employing feed-forward techniques to cancel the instrument disturbance torques and a newly developed 90mN (20mlbf) hydrazine micro-thruster along with arcjet thrusters, the observatory can maintain all performance requirements – even while offloading the reaction wheels or during station-keeping maneuvers.





The Geostationary Lightning Mapper (GLM) is an optical transient detector and imager operating in the near-IR that maps total lightning (in-cloud and cloud-to-ground) activity



The rigid external core structure of the first GOES-R is currently being integrated with the satellite's propulsion system at NASA's Stennis Space Center. Photo: ATK Aerospace

In addition, an active vibration damping (AVD) control system provides a damping control method for reducing spacecraft structural vibrations and improving antenna and instrument pointing. Together, these techniques and features provide nearly continuous observations by the instruments – unprecedented in GOES history.

GOES-R will collect and transmit at up to 100Mbps on its X-band downlink, and will continuously rebroadcast L1b/L2 ground processed instrument data on its dual-polarized L-band link. Other services supported are search and rescue, Data Collection System and Emergency Managers Weather Information Network.

The way ahead

The first satellite in the GOES-R series is scheduled to launch from Cape Canaveral Air Force Station, Florida, aboard a United Launch Alliance Atlas V rocket in late 2015.

NASA, which partners with NOAA in the acquisition and development of the GOES-R series, exercised an option for Lockheed Martin to build two additional satellites, bringing the total number of GOES-R series satellites to be built to four. This will extend the life of the GOES series to at least 2036.

When it comes online, GOES-R will inaugurate a new era of weather satellites. It will arm weather forecasters with even more precision information to provide communities with earlier and accurate forewarning to minimize loss of life and property and to provide greater accuracy for storm tracking. ∎

Paula Hartley is Lockheed Martin vice president and GOES-R program manager, based in the USA

KEY INSTRUMENTS

Advanced Baseline Imager

This is the main instrument on GOES-R for providing Earth imagery. The ABI will be able to view Earth with 16 separate spectral bands, including two visible channels, four near-infrared channels and 10 infrared channels. It will offer five times faster coverage than the current GOES satellites.

Presently, GOES can send updates over the entire western hemisphere every 30 minutes; GOES-R will accelerate that to every five minutes. And when set in a special operating mode, the ABI will offer repeat views of evolving storms over small areas every 30 seconds, which means weather forecasters will be able to track the development of storms in their earliest stages.

GOES-R will enable forecasters to finely monitor hurricane direction and landfall, which will help narrow the 'cone of uncertainty' for projected storm tracks. This enhanced accuracy will allow emergency managers and civil authorities to save resources by having to evacuate fewer people out of the way of an approaching hurricane.

Geostationary Lightning Mapper

The GLM is a revolutionary instrument that will map total lightning (cloud-to-cloud and cloud-to-ground) over the Americas and adjacent oceans to provide earlier indications of storm intensification and improved tornado warning lead times.

Changes in cloud-to-cloud lightning are related to the updraft strength in a thunderstorm. A rapid increase of the in-cloud lightning frequency, which is called a storm's 'jump signature', has been shown to precede severe weather at the ground by as much as 30 minutes.

The USA has more than 100,000 thunderstorms annually. To meet the requirements of real-time lightning mapping within thunderstorms across the country, the GLM's focal plane is composed of 1.6 million pixels monitoring all North America simultaneously. The focal plane is clocked at 500 frames per second to detect very fast lightning events. Also, because the GLM is a nowcasting instrument, it has a tight data latency requirement. The time from the moment the GLM detects a lighting event on its focal plane in space to the completion of its ground-based software processing – that is, when the lightning data is available to the severe weather forecasters – is less than 10 seconds.

The GLM's 'total lightning' observations of thunderstorms will provide US National Weather Service forecasters with advanced severe weather prediction capabilities to increase warning lead times and decrease false alarms.

Solar Ultraviolet Imager

The SUVI is a telescope that will monitor the sun's activity in the extreme ultraviolet (EUV) range. It will detect and calibrate active areas, solar flares and eruptions that can produce space weather affecting Earth, such as through disruption of power utilities, communication and navigation systems and by potential damage to satellites. SUVI provides full-disk images every 10 seconds with a resolution of 5 arc sec. Employing six EUV band passes enables observation of features such as coronal holes and flares.

Magnetometer

GOES-R will employ a magnetometer to measure the space environment magnetic field. Field measurements will alert satellite operators and power utilities. Data will also be used in research.

The magnetometer instrument will map the space environment that controls charged particle dynamics in the outer region of the magnetosphere and determine the general level of geomagnetic activity. The instrument will detect magnetopause crossings, sudden commencements of magnetic storms and sub-storms.

Space Environment In-Situ Sensor Suite (SEISS)

The five sensors that comprise the SEISS instrument will monitor the space charged-particle environment in real time, measuring geomagnetically trapped electrons and protons, heavy ions of direct solar origin, and background particles.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WEATHER WISE
WITH GOES-R
The Geostationary Operational Environmental Satellite system. For decades it has delivered reliable weather forecasts, helping people work and travel under stormy skies with confidence. Now a NOAA-NASA-Lockheed Martin team is building a more capable system, GOES-R, with powerful new instruments to capture more accurate and timely weather data. GOES-R. Because families, businesses and nations depend on it.
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We never forget who we're working for®

by Christopher Hounsfield

BAND ON THE RUN

One company stands out in weather radar development

EEC company president Andrew John Israel discusses the applications of X-, S- and C-band radars, plus the latest series of Ranger class radars

In 1971, a group of radar engineers formed the company EEC in south Alabama with a vision to develop and manufacture affordable, high-quality meteorological radar systems for the worldwide market. By 1974, EEC was fully operational and producing C- and S-band weather radars. In that same year, EEC was selected by the US National Weather Service to replace 160 older radar systems across the USA. Those systems remained the backbone of the US radar network until 1988.

The company has recently brought out its latest Ranger series of radars. Operating on the shorter X-band wavelength, EEC's Ranger weather radars have built-in dual-polarity so they can detect tiny particles, such as high altitude water droplets or light snow, at short to mid-range distances. Andrew John Israel is the president and director of the company, and he answers a few pertinent questions:

Can you give a little background to how you came to this position and what encouraged you?

Since 1996, I've served in senior level operating roles in three engineering businesses responsible for marketing and selling complex products to technically demanding customers in different regions of the world. Two of these businesses were complete cradle-to-grave entities, responsible for novel research and development, product scale-up and proving, manufacture, delivery, installation and commissioning.

When we acquired EEC, I was excited about the opportunity to transfer the knowledge and skills I've gained over the past 30 years into the new EEC. I took the executive role in the company and was particularly encouraged to do this because I could see the company already had a solid foundation of passionate, dedicated individuals. I felt we could harness that passion and devotion to develop a fresh face for EEC and re-solidify our position in the weather radar industry.

Can you give a broad description of your radar systems?

Radar systems designed, manufactured and installed by EEC cover all technology areas of the commercial weather radar equipment market. EEC's product line includes a complete array of X-, C- and S-band weather radar systems. We provide customized solutions for clients around the globe that fit any need and survive every environment.

What sort of environments do the radar systems work in? Why are they necessary for prediction?

Our equipment works in all climates across the globe. Installation teams have had to drag systems up tropical jungle mountains where tracks are really just muddy ditches worn into the hills over millennia. We have helicoptered systems onto remote frozen snowy mountain peaks and installed systems in distant African desert climes, where sand storms are more common than rain storms. Many of our systems are being used in TV stations and universities. They operate for scientific study purposes, simple weather data collection and display.

Weather radar systems are key for observing specific kinds of weather heading in a certain direction. They are vital because they detect, often at very long distances, things like rain drop size, density, cloud volumes and depth, windspeeds, and direction of weather systems. This allows forecasters time to feed complex weather prediction models with large volumes of data, and time to refine and adjust the information in those models.

Recently, EEC has teamed with specialist centers such as the University of Oklahoma's Advanced Radar Research Center to develop software algorithms that allow for greater warning times, which help mitigate the risk in a severe weather situation. Predictability offers safer evacuation and preparation.

"We have radars in freezing temperatures on top of mountains, in desert areas with intense heat and sand, and in extremely moist climates"

How do the radar systems work in harsh climates?

EEC radar systems are currently installed in just about every climate. Before we ever install a system, we consider the specific client and environment. This helps guide our design phase. We take certain elements like high moisture, humidity and heat into consideration, and have measures in place to combat the potential for added stress on the system.

Currently we have radars in freezing temperatures on top of mountains, in desert areas with intense heat and sand, and in extremely moist climates. Our systems can travel and operate almost anywhere with the proactive measures we take to combat the elements.

What are the biggest problems you have faced from a technology point of view in gathering radar data?

We live in an age where technology is constantly evolving. Two years in the technological world is a lifetime. Our challenge is how we adapt and respond to all of this change. We frequently assess our software, develop updates, and release new versions to give our clients the most up-to-date user experience.

At the same time, it can be difficult to establish baseline technology for clients because of what it will cost them to constantly update their systems. Newer customers get the latest bells and whistles. This is rather inspiring from an innovation standpoint, but it also means a variety of customers are using multiple interfaces. The technological challenges are not impossible, and in fact, they're necessary to keep an industry like ours on the cutting edge.

Are there any 'breakthrough' technologies that you have incorporated into your radar systems?

We recently introduced a new product to the market that we are very excited about. Our new Ranger X1 and X5 units are high-performance, low-power X-band radars that were developed in partnership with the Advanced Radar Research Center.

These Ranger systems are very compact, weighing less than 400lb/180kg. They feature dual-polarization technology, advanced solid-state transmitters and very low power consumption. The systems include a full-featured display and Doppler processing through our super-sensitive IQ2 digital receiver and the most advanced pulse compression techniques available. It is really the perfect unit for mobile installations or fixed installations where space and infrastructure are scarce. This is a very affordable system that is opening up new markets for us, especially in the offshore oil exploration, hydrology and military sectors.

You do have varying types of radar (X, S, C) – can you briefly describe the uses of each and their limitations?

EEC produces a wide array of systems because every customer has slightly different needs and requirements. Radar is not a one-size-fits-all type of technology as there are many factors that determine what the right solution is for a particular client.

When considering the type of radar to deploy, you must look at the location where it will be sited. Is there any potential blockage from structures or terrain? What type of weather does the area experience and, of course, what is the available budget? The primary difference between X-, S- and C-band radars can essentially be boiled down to the amount of attenuation those wavelengths are susceptible to as they move through the atmosphere. Attenuation can basically be defined as how much a radar beam or wavelength is weakened as it moves downstream and passes through hydrometeors such as rain, ice and snow. The larger the wavelength, the less susceptible the radar beam is to attenuation, which provides a better effective range. You typically see longer wavelength S-band systems deployed when a large area of coverage is required. C-band has a shorter wavelength than the S-band, with the X-band being shorter still. The attenuation of shorter wavelengths has been greatly mitigated in recent years with new developments in dual polarization technology.

What is now, and what is next?

EEC recently acquired the satellite ground station business from Environmental Systems & Services, which has been a leading supplier of satellite ground stations to governments, academic institutions and commercial enterprises throughout Australia and Asia. This acquisition will take that growth to an entirely new level by leveraging EEC's core engineering capabilities and global marketing reach. Our customers rely heavily on radar and satellite data in their forecast operations. ∎

by Savy Mathur and Yunhui Zheng

LAYER ON LAYER

Latest uses and benefits of micro pulse lidar systems

Breakthroughs in the use of lidar measurements of aerosol profiles have improved meteorological models and applications

MPL and MiniMPL

Two versions of Micro Pulse Lidar have been developed: MPL, designed for automated observation of aerosols and clouds up to 25km, and MiniMPL, optimized for near-range atmospheric observation (up to 15km). Both feature durable coaxial transceiver design and sensitive single-photon detection

Advances in lidar technology in recent years have led to more sophisticated reporting of meteorological parameters for modeling and forecasting. From boundary layer dynamics to cloud layer mapping, lidars are fast becoming the instrument of choice for high spatial and temporal resolution atmospheric measurements.

In both standalone and networked configurations, Sigma Space Corporation's Micro Pulse Lidar (MPL) and Mini Micro Pulse Lidar (MiniMPL) instrument suites provide a complete scenario of local and regional atmospheric trends. Meteorological science has advanced to a point where every measurable parameter of our atmosphere can be used to make forecasting more accurate and reliable. Many efforts have been made to characterize the properties of aerosols, which are important in lower atmospheric dynamics. Although there are existing instruments that can measure properties of aerosols precisely, they provide only in-situ measurements, so the data reveals trends at ground level but not at higher altitudes.

The lack of a complete picture of aerosol vertical profiles makes forecasting and understanding these lower atmospheric events more difficult. A lidar, on the other hand, offers the required aerosol remote sensing capability, at unprecedented ease and low cost. It can operate unattended, around the clock, generating remote sensing data every minute, in contrast to traditional balloon-based radiosondes, which generally offer twice-a-day profile data. Operating on the same principles as radars, lidars are able to take measurements of molecules and aerosols, rather than only much bigger particles such as rain droplets. From the raw data, numerous algorithms can and have been created to mine many types of useful information.

Micro Pulse Lidar (MPL) technology

Lidar was first developed in the early 1960s, using spot beams and lasers for ranging applications. During the research and development stages, these systems were bulky, expensive installations, requiring frequent attention. For large-scale deployments such as meteorological networks, lidars were usually prohibitively expensive and difficult to maintain.

Then, in the 1990s, leveraging the development of solid-state lasers, sensitive detectors and computing power, NASA developed the MPL system at its Goddard Space Flight Center in Greenbelt, Maryland. The system uses small laser pulse energy and a high pulse repetition

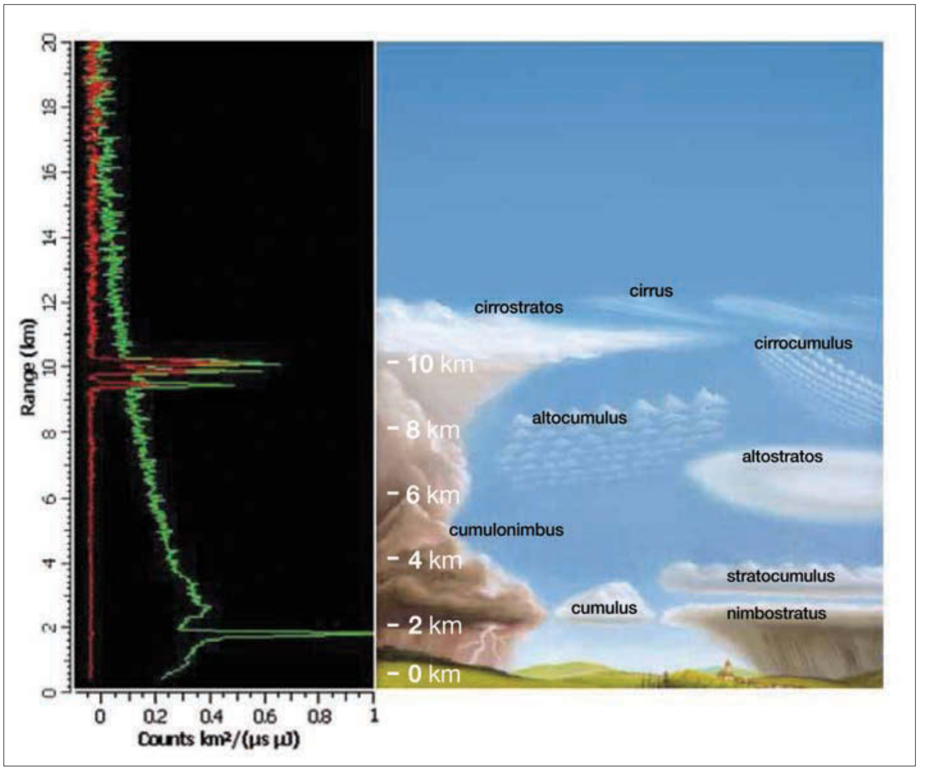


Figure 1: Vertical aerosol profile of clouds produced by MiniMPL; a cloud diagram is shown on the right for illustration purposes. The aerosol profile is a 30-second averaged profile of normalized relative backscatter (NRB) intensity, indicating a thin water cloud near 2km (green peak), and multiple layers of clouds containing both water and ice in the 9-10km range (green and red peaks)

rate to make an eye-safe system that was initially used for aerosol and cloud research. Present-day MPLs are designed as turnkey instruments for ease of deployment and use.

The MPL transmits laser pulses that scatter or reflect off droplets or particles in the atmosphere. The intensity of backscattered light is measured using sensitive, photon-counting detectors, and the results are then transformed into atmospheric information in real time. Today, the MPL systems offer increased sensitivity to detect both solid targets and diffuse targets such as aerosols or molecular species even in dense haze and fog or other poor weather conditions.

Under a technology transfer from NASA, since 2004 Maryland-based, Sigma Space has been delivering powerful and versatile MPL systems while improving the capability, portability and affordability of this sophisticated technology. With many generations of the MPL now in use worldwide, Sigma Space has made lidar technology cost-effective for both the individual researcher using one lidar and networks with multiple air monitoring stations spread over vast regions.

Unattended atmospheric profiles 24/7

There is an increasing need for unattended atmospheric profile monitoring. Tracking the optical properties of clouds and aerosols in the atmosphere with MPL requires no maintenance or attention during data collection and processing. Data interpretation can be enhanced for a single event by providing multiple profiles and perspectives using auxiliary information from surface weather sensors and images of the sky.

A recent addition to the MPL product family, the MiniMPL is optimized for aerosol profile measurement up to 15km. It offers a cost-effective, lightweight and mobile solution for users studying cloud or lower atmosphere aerosol dynamics, and incorporates an optical transceiver unit and a computer. The transceiver houses the laser transmitter, which operates at 532nm wavelength, and the photon-counting detection system. The range-resolved signal is transmitted and received using a common built-in athermal telescope, and displayed in real time on the computer. To facilitate portability, the optical transceiver is integrated with the electronic system, and the data-acquisition software provided can also be used to play back data files recorded previously. Like the MPL, the MiniMPL operation is fully automated and designed for unattended data acquisition. It can detect planetary boundary layer (PBL), continuous aerosol top layer, cloud base and top layer, and the detection of the PBL is unaffected by the presence of clouds so no data smoothing is necessary. It also has dual polarization sensing that enables characterization of irregularly shaped particles, such as ice particles in high range cirrus clouds, and can address the needs of anything from fixed sites to field campaigns without losing accuracy in tracking aerosol transport and aerosol mixing into surface layers of air.

Thus, MPL systems are able to collect the detailed, real-time cloud data needed for industry-leading forecasts, accurate weather models, and optimal air traffic support. Together with boundary layer dynamics, this information can be used to forecast frontal passages.

Cloud structure determination, identification and aviation

MPL systems' vertically resolved, ground-based measurements complement satellite images by providing detailed information about cloud height, extent and structure. These properties are key to forecasting, as they are directly related to atmospheric processes below and within the clouds. Using cloud height (pressure level), optical thickness and signal depolarization, Sigma Space MPL software quickly and accurately classifies cloud types and structures such as stratocumulus and cirrus.

Using polarization data, this technology can determine whether clouds contain liquid, ice or both. The software also includes algorithms to automatically mark other important features, including the PBL, cloud base, cloud top and thickness.

Furthermore, in addition to improving weather models, MPL cloud profiles provide detailed information to air traffic control for pilots operating under visual flight rules (VFR) or instrument flight rules (IFR) near airports, enhancing aviation safety.

Vertical aerosol profile and time sequence plot

MPLs measure aerosol type, structure and layers, and display these characteristics in two basic kinds of plots – vertical aerosol profile (Figure 1) and time sequence plot. Figure 1 is a snapshot of atmospheric aerosols that depict backscatter intensity versus distance (range). Generally, a profile is generated every 30 seconds, with a 30m range resolution (both parameters are adjustable, with the finest resolution being 5m and 1s). Profile features include peaks

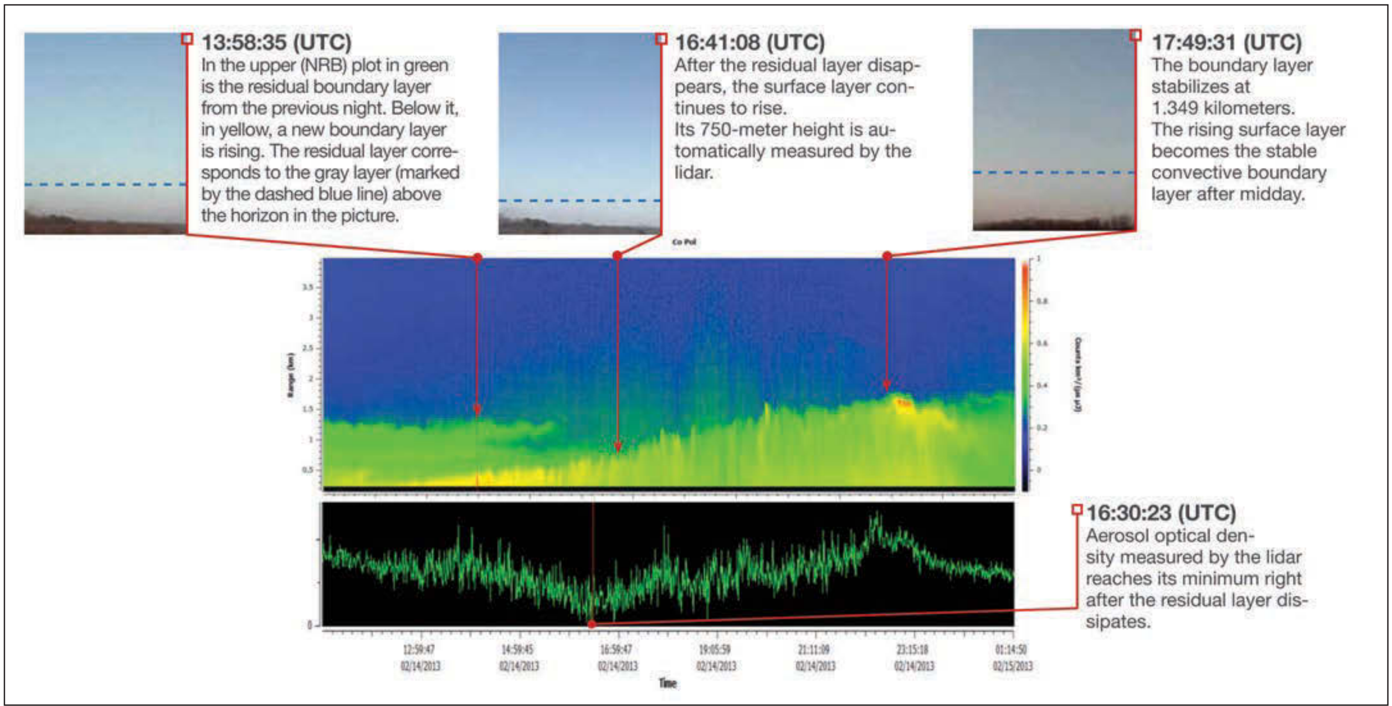


Figure 2: Local PBL dynamics captured by Sigma's lidar sensor suite. Top: Weather camera images and records the PBL height fall and rise on the horizon. Middle: Lidar return signal (height versus time and scattering (color scale) shows exactly how PBL height rises with the sun rising. Bottom: The total column aerosol optical density, which is an indicator of the level of air pollution, is also derived from the integrated lidar signal

that correspond to aerosol or cloud layers, green traces representing co-polarized (same as laser transmitter) backscatter (orthogonal to laser) returned by both spherical particles (liquid droplets) and asymmetric particles (ash and ice), and red traces representing cross-polarized backscatter returned only by asymmetric particles. A time-sequence plot (Figure 2) is a pseudo-color plot that shows temporal (horizontal) and spatial (vertical) trends in aerosol and cloud structure, providing information on developing weather fronts. Normalized relative backscatter (NRB) intensity is represented on a color scale, with data updated in real time.

Synchronization of multiple instrument data streams

The MPL and MiniMPL systems can be deployed with a series of supporting instruments including a ground weather station measuring standard parameters (including temperature, humidity, dew point, wind direction and speed, barometric pressure, rain rate at the sensor, and temperature and humidity at the base station); a geographic information system using Google Maps; a new volcanic ash detection algorithm; and an all-sky weather camera that can photograph conditions during lidar data collection to analyze with MPL data.

With automated data collection and real-time monitoring, this lidar suite frees forecasters to deploy and return at their convenience, without compromising the quality or resolution of the data. Available from Sigma Space, it works seamlessly with the Sigma MPL software, which also has an open structure to accommodate third-party data streams such as radiosonde and sun photometer input. This information can be synchronized with lidar data and/or serve as calibration data.

Planetary boundary layer

The PBL is the lowest region of the atmosphere, and its qualities and behavior are directly influenced by its contact with the Earth's surface. PBL height is dynamic and data about it is essential for calculations of top-down emissions estimates.

Scientists regularly use PBL data to produce inventories of greenhouse gases and other pollutants. However, because of its constantly changing state and tremendous impact on the other layers of the atmosphere, PBL height also serves as an important input parameter for any weather forecasting model. In the past, PBL height has typically been measured twice per day by a sonde, but can now be measured automatically and continuously using lidar, with superior signal-to-noise ratio and high spatial resolution.

MPL systems are ideal for PBL profiling across applications since their sensitivity can easily detect the aerosols that accumulate and are mixed in this layer. In fact, they can detect PBL layers through cloud decks at any time of day, and in both seasonal or mildly inclement weather, without spatial filtering. These measurements – combined with data streams from the MPL suite using images, optical density and surface observations – enhance the understanding of boundary layer processes far more than using lidar backscatter data alone.

Sigma MPL software is versatile and fully automated to perform data acquisition and processing, and the US company is delivering a growing and continually improving range of atmospheric data products to serve a diverse customer base.

From the outset, Sigma Space MPL systems have served as powerful atmospheric research instruments, quickly gaining ground in applications including cloud mapping, air quality and greenhouse gases monitoring, aviation safety and military applications. Much of this success is due to the technology's versatility and ability to combine lidar data with real-time information from other instruments, helping to provide a more complete picture of the atmosphere around user needs. ∎

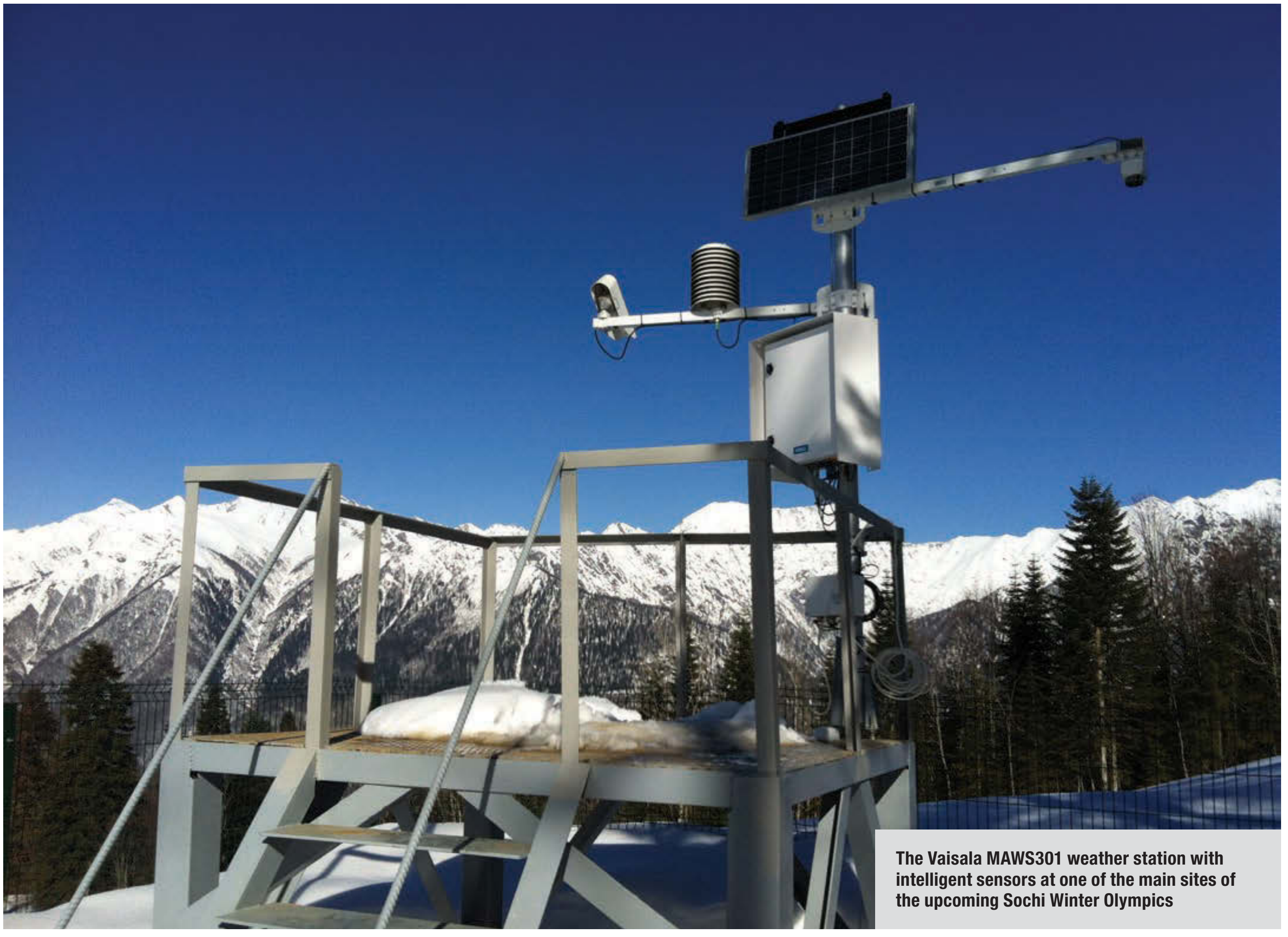
Savy Mathur is program manager and Yunhui Zheng is product manager of MPL with Sigma Space Corporation in the USA

by Johanna Rämö

MANUAL TO AUTO

The basics of how to design a reliable surface weather system

Data quality from weather sensors combined with end-user information can combine to improve collection systems and provide more intelligent and stable devices



The Vaisala MAWS301 weather station with intelligent sensors at one of the main sites of the upcoming Sochi Winter Olympics

When designing and manufacturing new weather station systems, a data collection system with a high reliability is essential. This can be achieved with stable intelligent sensors, a versatile logger, and easy-to-use on-site calibration equipment.

Weather near to the surface of the planet has a strong impact on the environment and the way we live. Weather phenomena at the surface originate in the upper layers of the atmosphere. However, conditions on the surface of the planet also influence the upper air conditions. Surface weather data is widely collected and used as source data in weather forecasting and verifications, climate research and weather modeling. Therefore, surface weather data plays a remarkable role in understanding our complicated weather systems.

Surface weather can be measured using various techniques and instrumentation. For decades, Finland-based Vaisala has manufactured surface weather instruments, covering pressure, temperature, wind, precipitation, visibility, cloud height and carbon dioxide instrumentation. The latest weather station product, the MAWS310 weather station for meteorological use, has just been launched.

Automatic data collection

Thirty years ago, all surface measurements were collected manually. Data from distant sites was sent via telephone lines and fax, or in letters sent to a central data collection center. Nowadays, a major part of the surface weather data collected is gathered using automatic weather stations. The change from manual to automatic data collection has been a big step forward in the field of meteorology, increasing the amount of meteorological data collected and improving the reliability and accuracy of the measurements.

Surface weather system design

The basic functions of a weather station are to collect data from surface weather sensors, process the data and send it on to a database. To complete these tasks, a weather station system consists of sensors and several electronic components, as well as supporting components such as masts and cross arms.

The components are fitted together to make a system that the customer can rely on. This may sound easy, but designing a complete system actually requires a deep knowledge of system electronics, different types of software and environmental challenges, such as lightning protection, corrosion protection and mast wind loads. The operation of the weather station is not acceptable until the data is received at the meteorological office. The reliability of a surface weather system is very important as the measurement sites are often in remote locations where technical help is not nearby.

The targeted application is known in the product design and component selection phase. A weather station system can be designed to fulfill the needs of specific applications, such as hydrological or agricultural. These systems are designed to make a limited number of specific measurements with standardized system components.

A system can also be designed to be more general, for use in a number of different meteorological applications. These systems require a flexible system structure and versatile data logger, and they are often customized so as to adapt to the user's specific environment. Manufacturing high volumes of unique systems is a major challenge for the manufacturing process. That is why weather station manufacturers tend to pre-configure and standardize part of the system integration and components, while still leaving space for some specific customer modifications.

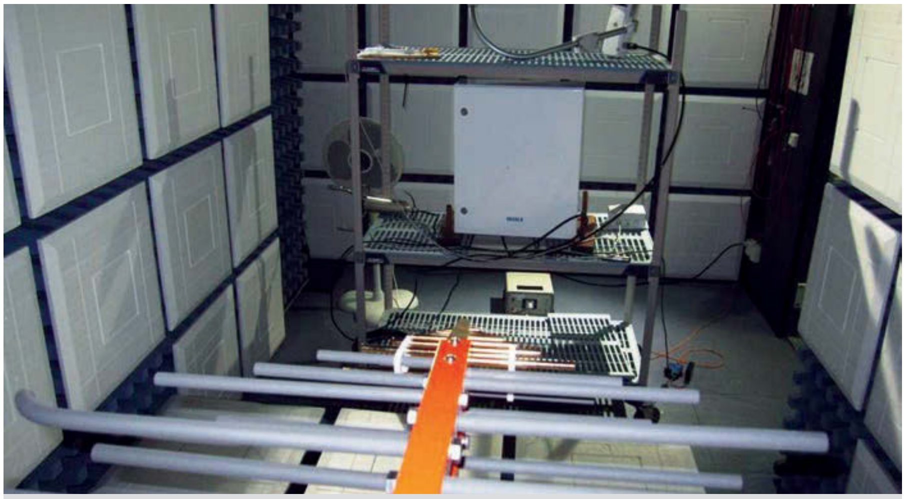
The new Vaisala AWS310 weather station system

"An intelligent datalogger enables flexible telemetry and power control programming"

Intelligent datalogger

A logger controls automatic operations in the weather station. The logger receives sensor data, validates the data, applies algorithms to compute the desired parameters, and then saves the data in the memory or sends it on using some form of telecommunication. An intelligent datalogger enables flexible telemetry and power control programming, as well as implementation of customer-specific weather calculation algorithms. Firmware

Vaisala PTB330TS field-checking equipment for pressure, humidity and temperature



Electromagnetic compatibility testing of a weather station

updates can also be automated – a modern datalogger is able to upgrade its firmware automatically from the network without needing site operations.

The basic set of measurements at a meteorological site consists of wind, humidity, temperature, air pressure, solar radiation and precipitation. The set of selected sensors depends on the desired application and required data quality. Accuracy and resolution specifications are the basis for the sensor selection. When top accuracy performance is required, in climatology or environmental research for example, the instrument is selected from among the high-performance instruments. Nowadays, long-term stability and durability may be preferred over accuracy. Selection is typically made by optimizing the cost/performance ratio. Weather stations with versatile and intelligent loggers can communicate with a wide range of sensors. Today, a major proportion of meteorological sensors are serial sensors. However, there are still parameters that are usually measured with analog devices, such as solar radiation, soil temperature and soil moisture.

The trend in sensor development at the moment is to produce intelligent sensors. Intelligent instruments communicate with data collection systems using a serial line. Intelligence also means the sensor's ability to communicate its state, warn of errors or indicate its need for calibration. These properties enable improved remote maintenance, which decreases the number of expensive site visits. Nowadays, an intelligent sensor can also process data and make internal calculations and validations.

Increased processing may increase power consumption. As surface weather measurement instruments are often powered by the sun, power consumption is one of the most important features in the system. Thus, balancing the sensor performance and power consumption is one of the modern challenges in instrument design.

Weather station enclosure – test

Testing is an essential part of the product development process. Product tests confirm to the manufacturer and customer that the design fulfills the specified requirements. In weather stations, most electrical components (except sensors) are located inside a weather-proof enclosure. The weather station enclosure should pass environmental, transportation, storage, electromagnetic compatibility and electrical safety testing.

CUSTOMER DOCUMENTATION, TRAINING AND TECHNICAL SUPPORT

Reliable weather data is not achieved without skilled technical personnel to operate and maintain weather systems. Weather systems should always be provided with clear documentation of the overall system architecture and detailed wiring diagrams. In addition, user manuals and maintenance instructions for the weather station and each sensor must be provided to ensure correct installation and implementation. When taking new systems into use, technical training is more than recommended. Technical support from the manufacturer is also needed, especially when integrating weather station systems into a customer's existing data-collection system.

Environmental testing includes dry heat, damp heat and cold tests. Transportation durability is tested against vibration and rough handling. In addition to hardware, the software is also tested with all possible sensor and telemetry system combinations. All pre-configured meteorological calculations, units, data validations and algorithms are checked to ensure the highest quality data. After successful testing, the manufacturer can verify the quality with test certificates.

Consider calibration before purchase

The weather sensors are often calibrated at the factory, but even the most accurate factory calibration is not a guarantee for lifetime accuracy. As time goes by, most sensors start to drift as they are exposed to changing temperatures and humidity conditions, and various chemical compounds in the air. To maintain their accuracy, weather sensors need frequent calibration and maintenance. Weather instruments typically need to be calibrated every year or two. Calibration maintenance is the basis for good data quality.

Designing a good weather system requires accurate weather sensors and a professionally made data collection system. In addition, systems must be operated correctly and maintained continuously. It is not enough to have a lot of data – the quality of the data has to be good. In the manufacturing field there is still a lot to do: more intelligent and stable devices should be developed. Users should also be committed to improving quality at all points of the observation system with scheduled calibrations and maintenance. ∎

Johanna Rämö is the application manager with Vaisala Oyj based in Finland

by Andres Thorarinsson

WEB WEATHER

Professional services that can provide real-time weather data and its long-time trends

By visiting special websites for field data, you can bypass the middle man and check the facts yourself

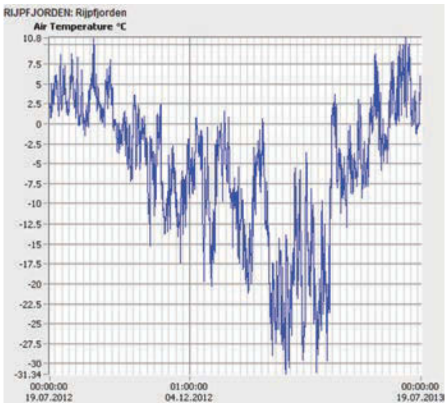
Think about all the instrumental grade weather sensors that have been sold worldwide over the past few years. Where are they? And all the dataloggers, backbones of every weather measurement system? Most likely there are tens of thousands of dataloggers out there and millions of sensors. Is there open access to data from any of these systems?

Indeed there is – and the following information is open to all via the corresponding websites.

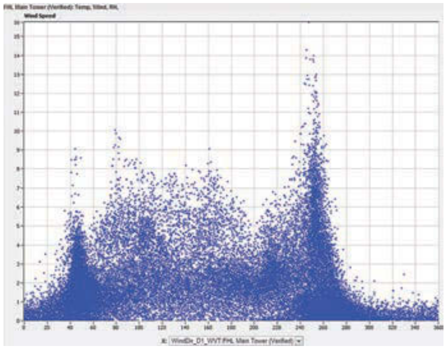
Svalbard is a group of islands in the North Atlantic, far north of Iceland, east of the northern part of Greenland, ranging from 74° to 81° north, 10° to 35° east. What is the weather like up there?

Anyone who wants to know can make use of the numerous automatic weather stations in the area, operated by the University Centre in Svalbard. There are seven stations close to the village of Longyearbyen and two further east and north. The real-time weather and trend lines are accessible at www.unis.no, from the link 'Weather'. At the time of writing, the air temperature at noon at Rijpfjorden was around freezing.

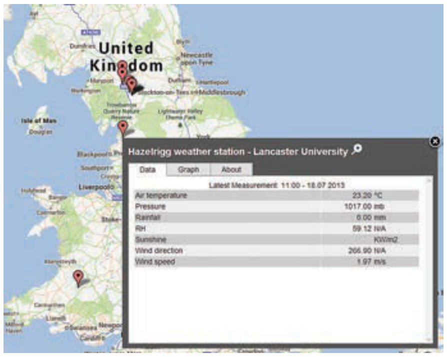
The University of Washington runs Friday Harbor Laboratories (FHL), a world-renowned centre for marine biology and oceanography, on the island of San Juan in the Strait of Juan de Fuca, north of Seattle, Washington. Since 2006 an automatic weather station has logged all the most important weather elements and stored the information in a database. This weather data is accessible at the university's website (www.washington.edu). A search for 'weather station' will find FHL Weather Station, which in turn provides direct access to the data. Looking at the wind direction



One year of air temperature measurements in degrees Celsius at Rijpfjorden weather station at 80° north. It is interesting to see the great temperature variations throughout the year



Graph showing one year of wind direction and windspeed measurements at Friday Harbor Laboratories. Clearly, the most common wind directions are 45° and 250°



All measurements from the Hazelrigg weather station are available on a Google Map interface

data, it is interesting to notice that wind has a strong two-directional character, either into or out of the strait.

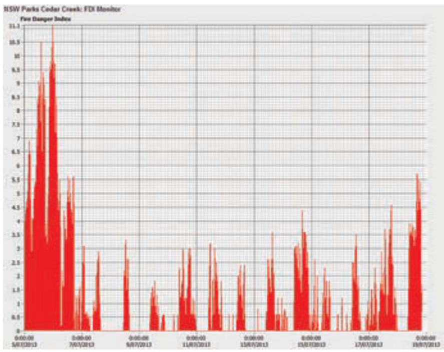
Lancaster University in the UK is 10km from the Irish Sea, just south of the city of Lancaster and close to the Lake District. Its website (www.lancaster.ac.uk) opens the door to weather measurements run by the Lancaster Environment Centre at Lancaster University. A search for 'weather station' will point to Hazelrigg Weather Station and at the bottom of that page is the link to Hazelrigg Automated Meteorology Measurements. Via a Google Map interface there is access to the Hazelrigg weather data as well as data from a few other weather stations around the UK.

Australia has its share of bush fires, with several major incidents every year and countless smaller ones. They are dangerous and costly, so automatic weather stations have been installed to help predict the likelihood of new fires. These weather stations calculate the Fire Danger Index based on temperature, humidity, precipitation and other factors. The Windellama Rural Fire Brigade in NSW has an interesting website (www.windellama.bushfirebrigade.com.au/windellama_rfs_about_us.php) showing not only the current weather but also, more interestingly, gives a link at the top of the page to the real-time website (www.teledata.com.au) with FDI information. Once you sign in using the username/password indicated you have access to real-time data from 30 automatic weather stations, all delivering FDI data as well as general weather readings.

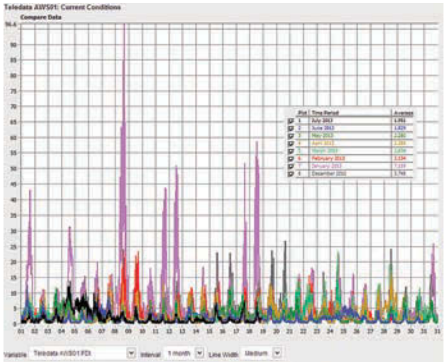
One of the interesting things about weather data management systems is the ability to be able to report data in such a way that important trends in the data become clear. One such report is the overlay data report, where each month's data is plotted on top of previous data.

With all this information so readily available, it's easy to access weather data with your fingertips and understand better all the variations in weather and how weather parameters interact. ∎

Andres Thorarinsson is CEO of Vista Data Vision based in Iceland



Fire Danger Index (FDI) as calculated in real time at Cedar Creek. July is winter in Australia; in the summer the FDI may be much higher at between 50 and 100



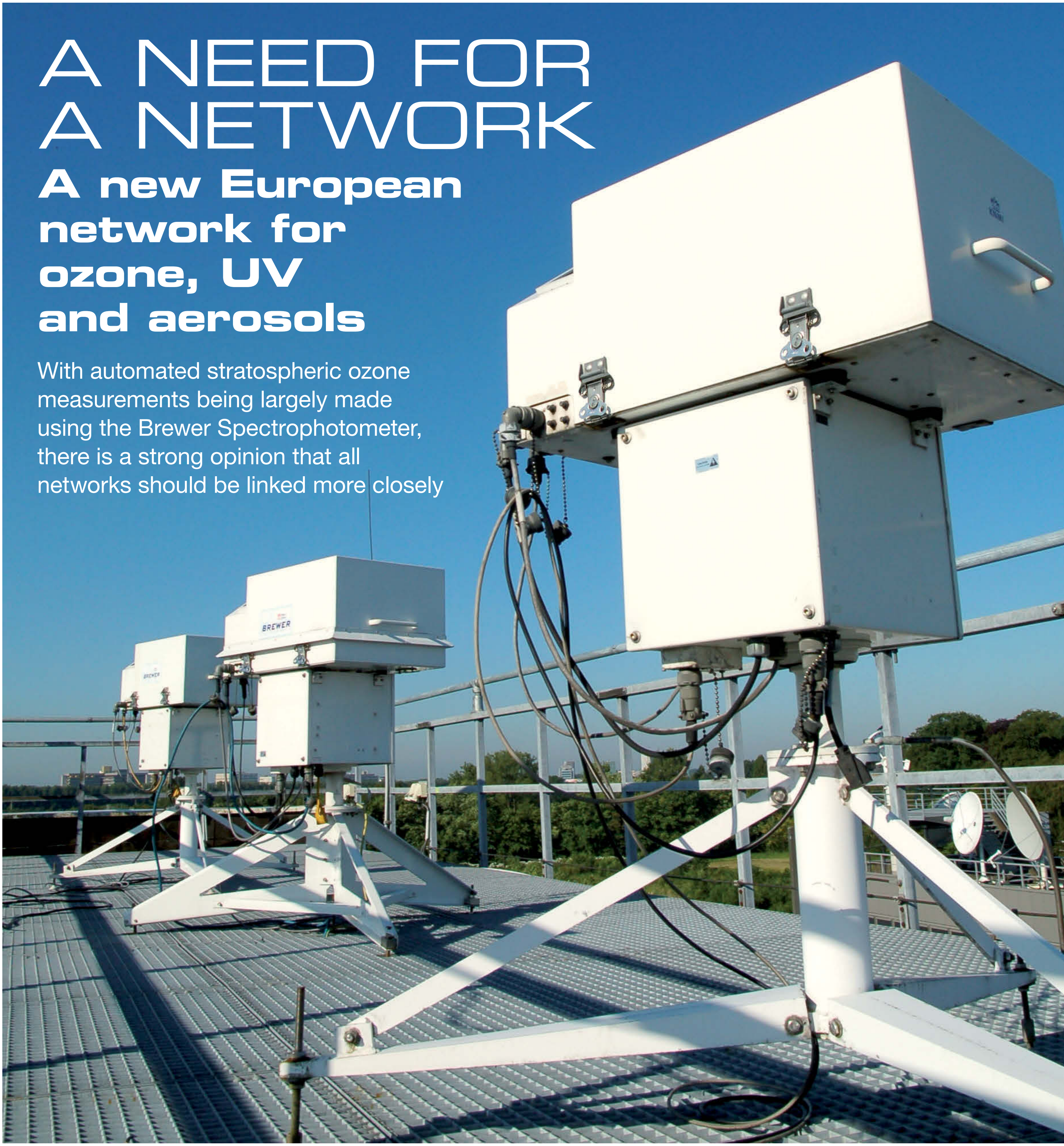
FDI for eight months plotted as an overlay data report. It is clear that the highest FDI was in January 2013, with a few highs of 50 and a maximum of 97

by Clive Lee

A NEED FOR A NETWORK

A new European network for ozone, UV and aerosols

With automated stratospheric ozone measurements being largely made using the Brewer Spectrophotometer, there is a strong opinion that all networks should be linked more closely



> "One of the key objectives is to build capacity by connecting high-quality scientific communities throughout Europe and worldwide"

Below: European Brewer Inter-comparison – Huelva, Spain

A major concern in many parts of the world is the amount of harmful ultraviolet (UV) radiation from the sun and sky that people are exposed to. The UV part of the solar spectrum has several beneficial effects for human biology, but too much can be harmful. The UV region covers the wavelength ranges 100-280nm (UVC), 280-315nm (UVB) and 315-400nm (UVA). Almost all UVC, and approximately 90% of UVB, from the sun is absorbed by the Earth's atmosphere. UVA radiation at the Earth's surface is normally 15-20 times greater than UVB.

UV radiation helps to produce vitamin D, but it can also burn the skin and cause cancers, melanoma and cataracts. UV radiation measured with a similar response to the human skin is termed erythemally active UV irradiance (UVE), and this must be used to calculate the Global Solar UV Index (UVI) for public health information. UV radiation also affects terrestrial and aquatic ecosystems, agriculture, air quality and materials, and atmospheric chemistry. There is an increasing need for widely distributed, near real-time, high accuracy spectral UV measurements.

A reduction in stratospheric ozone means that more harmful UV reaches the ground. The state of the ozone layer is also an indicator of the general health of the atmosphere. The Vienna Convention for the Protection of the Ozone Layer was signed in 1985 to promote research and information exchange on the science of ozone depletion, including monitoring of total ozone column and spectrally resolved solar ultraviolet radiation. A protocol to the convention came into force in January 1989 – the Montreal Protocol on Substances that Deplete the Ozone Layer.

The hole story

'Holes' in the ozone layer are areas where stratospheric ozone is depleted by 25% or more, and are not confined to the Antarctic. The first Arctic ozone hole appeared in 2011.

With the increasing interest in climate change and global warming research, the effects of stratospheric aerosols are being studied in greater detail. Primarily, this refers to water vapor and suspended particles such as smoke, dust, sand and volcanic ash. These absorb and scatter solar radiation, act as nuclei for the formation of clouds, and promote atmospheric chemical reactions. Understanding atmospheric aerosols is one of the most important ways that scientists can improve models for weather and air quality forecasting, and for climate change prediction. There are a number of existing groups and networks within Europe that monitor aerosols, but these are generally in the visible and near-infrared wavelength bands.

Automated stratospheric ozone measurements worldwide are largely made using the Brewer UV Spectrophotometer. This instrument also makes spectral UV measurements and aerosol information can be derived from the data. All three parameters can be measured in the same place and in the same timeframe. There are more than 50 Brewers across Europe. The majority of instruments are independently operated by national agencies, as required by the Vienna Convention, with differences in operation, measurement strategies, data processing and calibration. There is currently no formal European Brewer Network and related regional database capable of providing spatially consistent data to a high degree of accuracy with a common scale of quality assurance.

Scientific networks

COST is an intergovernmental framework for European Cooperation in Science and Technology, enabling the coordination of nationally funded research on a European level. One of the key objectives is to build capacity by connecting high-quality scientific communities throughout Europe and worldwide.

The European Brewer Network, or EUBREWNET, is the European Concerted Research Action in Earth System Science and Environmental Management (ESSEM) – designated as COST Action ES1207: A European Brewer Network. EUBREWNET was approved in Brussels in November 2012.

The objective of the action is to coordinate Brewer Spectrophotometer measurements of total column ozone, solar radiation and aerosol optical depth (AOD) in the UV part of the spectrum within Europe. This will be achieved by uniting the ozone, UV and AOD communities, through a formally managed European Brewer Network capable of delivering a consistent, spatially homogeneous European data resource.

In the future, this will ultimately provide the added value of near real-time, high-quality, spatially homogeneous data sets for public information, policy decisions and scientific input to important atmospheric and environmental projects within the European Research Area and globally.

This action will be significant for the World Meteorological Organization (WMO), the World Ozone and Ultraviolet Radiation Data Centre (WOUDC), the International Ozone Commission (IO3C), the Intergovernmental Panel on Climate Change (IPCC), Global Monitoring for Environment and Security (GMES), and the ozone trend assessment panels.

Above: Brewer MkIII Spectrophotometer in Tenerife

Stratospheric ozone measurement

Gordon Miller Bourne Dobson (1889-1976) was a British scientist who devoted much of his life to the observation and study of atmospheric ozone, mainly at the University of Oxford. The results were to be of great importance in leading to an understanding of the structure and circulation of the stratosphere.

In order to make measurements of ozone in the stratosphere he designed the Dobson Photoelectric Spectrophotometer, using the sun as the light source.

Ozone research became organized under the International Ozone Commission, which was set up in 1948, with the Dobson Unit (DU) as the measurement quantity for total column of atmospheric ozone. The global average value is about 300 DU and the boundary of an ozone hole is normally defined as 220 DU.

Dr Alan West Brewer (1915-2007) was a British-Canadian physicist who joined Professor Dobson at Oxford in 1948. The main problems with the Dobson Spectrophotometer are that it is manually operated, very large and heavy, and can only measure ozone. To address these issues, Brewer and Dr David Wardle, then a lecturer at the University of Toronto, began to develop an automated instrument to measure ozone.

The Brewer is an automated, diffraction-grating spectrometer that provides near-simultaneous observations of the sun's intensity at six wavelengths in the near UV. The data is used to calculate the total column of ozone and sulfur dioxide, and the aerosol optical depth. The thickness of the ozone layer is determined by comparing the intensity of solar radiation at different wavelengths in the ultraviolet that experience very different absorption by ozone in passing through the atmosphere.

The Brewer

The Brewer points at the sun using a moving internal prism and an azimuth tracker with a heavy-duty tripod stand. It makes measurements of the direct solar UV radiation at specific wavelengths to determine the total column ozone and sulfur dioxide in the atmosphere. It also has the capability to make high-resolution UV spectral scans of either the direct or the global solar radiation in the wavelength range from 286.5nm to 363nm, with a resolution of 0.6nm. From the measurement data, aerosol optical depth can be calculated.

It is the only spectrophotometer that can operate continuously outdoors, and provide automatic observations of total column ozone and sulfur dioxide, spectral UV radiation and aerosol information, in all climates and environments from the tropics to Antarctica.

The current model is the Brewer MkIII, with two monochromators in series. This gives the MkIII a significant advantage over the single spectrometer MkII and MkIV Brewers, which are no longer manufactured. It also has much improved performance at low solar elevations (high zenith angles), which is very important in polar regions.

Brewer MkIII Spectrophotometer

In 1988, the Brewer Spectrophotometer became the WMO Global Atmosphere Watch (GAW) standard for stratospheric ozone measurement and a reference Brewer 'Triad' was set up by Environment Canada in Toronto, along with the WOUDC. Europe has its own WMO-recognized Regional Brewer Calibration Centre for Europe (RBCC-E) at the Izaña Observatory on Tenerife. This center has a reference triad of MkIII Brewers.

EUBREWNET – The future

COST ES1207 will run for four years with the objective to amalgamate the independent national programs into a coordinated European network of Brewer Spectrophotometers. This will unite the ozone, UV and aerosol communities so that physical models used for remote sensing can be effectively optimized by combining knowledge and resources.

A key aim is to forge links between ground-based EUBREWNET and organizations dealing with satellite data validation; such as ESA, NASA and NOAA. It is also intended to correlate with the main visible/near infrared AOD networks within Europe; Global Atmosphere Watch-Precision Filter Radiometer (GAW-PFR), European Skynet Radiometer (ESR) network and Aerosol Robotic Network (AERONET).

Ultimately, EUBREWNET will be presented globally as a formal network with clear operational and data protocols and encompassing the RBCC-E reference triad. There will be a web portal with near real-time and historical data from across Europe that has been measured, validated and processed in a standardized manner. ∎

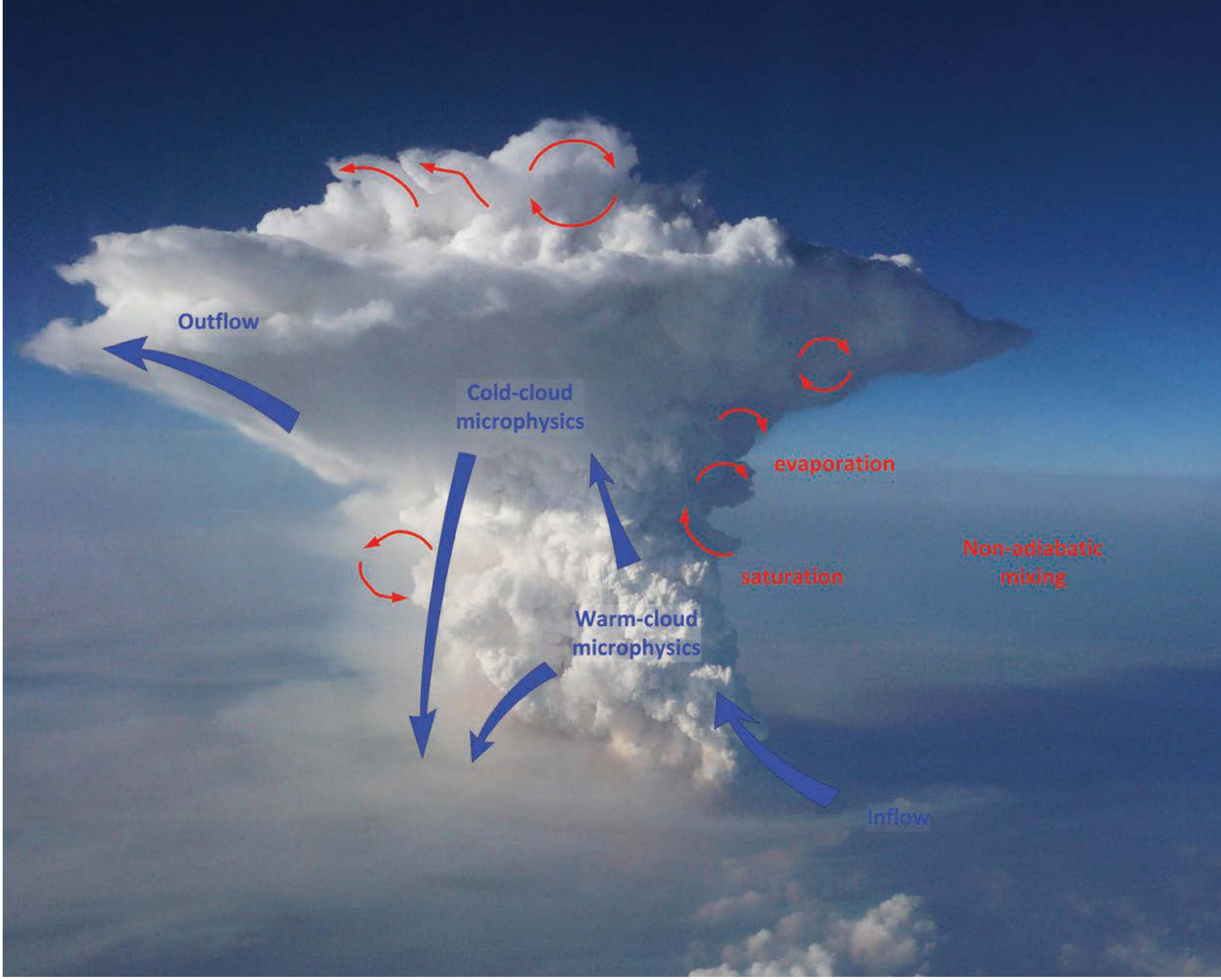
Clive Lee is a customer services specialist at Kipp & Zonen, based in the Netherlands. The EUBREWNET ES1207 Cost Action home page is http://www.cost.eu/domains_actions/essem/Actions/ES1207

by Roman Stepanov & Alexander Lukin

POSITIVE ENERGY

Using highly specialized models to predict storms

Thunderstorms and related dangerous weather can dramatically affect industry. One Russian organization highlights the impact on the energy sector



Thunderstorms are dangerous weather phenomena. They are often accompanied by gale force and hurricane winds, storm precipitation, hail and tornadoes that can cause colossal damage to a national economy and lead to loss of human life. Accordingly, many scientists are interested in the prediction of thunderstorms and all the accompanying phenomena.

The physical processes of thunderstorm formation and the accompanying dangerous weather phenomena are complicated and cannot be described by simple algorithms. Research into volume charge formation and spatial distribution, including ascending and descending flows in storm clouds, don't give a comprehensive idea of the physical processes arising in cumulonimbus clouds and are generally theoretical, which brings inaccurate and subjective interpretation.

There is a set of theories that describe thunderstorm origin and forecasting methods, but there is no method that's reliable and universal. Theories of volume charge origin and physical processes arising in storm clouds are ambiguous and sometimes contradictory. This is due to the lack of knowledge about storm phenomena formation processes.

It is because of this that thunderstorm forecasting is a complex challenge, particularly if it is necessary to give warnings a day ahead.

Data actuality for the energy industry

The energy industry is one of the weather-dependent branches of any national economy, because weather conditions have a direct impact on its function and trouble-free operation. Qualitative specialized weather forecasts, considering all local weather factors, are necessary to ensure trouble-free operation in the energy industry.

Russia's National Agency for Environmental Monitoring (NAMOS) is engaged in the development of highly specialized forecasts. The creation of a meteorological support system for industry needs is based on modern, highly precise, numerical methods of forecasting that use data from numerical weather prediction mesoscale models as input.

All objects in the energy industry are spread over a wide area and are therefore subject to the negative influence of dangerous weather. Thunderstorms are often accompanied by gale-force and hurricane winds, storm precipitation, hail and tornadoes. All these phenomena, along with lightning, can lead to serious accidents, damage to power lines and, consequently, major financial losses. According to power outage statistics, thunderstorms occur in 30% of all cases of industrial damage, which is why specialized forecasts of storm danger are necessary for scheduling operating personnel and to ensure an uninterrupted electricity supply for the consumer.

Problems with a qualitative thunderstorm forecast

All thunderstorms are directly connected to the development of powerful cumulonimbus clouds, which cause strong instability with air stratification at high humidity. Since thunderstorms can arise as atmospheric fronts (frontal thunderstorms), several techniques can develop out of thunderstorm forecasting. All are brought together to calculate the time and intensity of thermodynamic fluctuation instability in the storm area, taking into consideration the location and interaction of the air mass with a spreading surface.

All these forecast methods are based on the assumption that thunderstorm generation is an adiabatic process – that is, one that occurs without the exchange of heat between a system and its environment. This is the opposite of a diabatic process, in which heat exchange occurs through the movement of particles.

On the basis of these methods, thunderstorms can be predicted across vast territories quite reliably over a 24-hour period. Accurate forecasting is reduced to about six to nine hours.

Such methods are unsuitable for specialized forecasts for separate areas, because they don't give the 'field forecast', including convective instability with the probability of storm centers arising with different intensities and evolution over time.

As the energy industry needs an exact forecast of thunderstorm danger, with a warning time of about three days and showing territorial distribution of storm activity centers, a numerical hydrodynamic forecast method of the convective phenomena of thunderstorms has now been developed.

Numerical modeling

This method is based on numerical modeling of vertical non-adiabatic movement of conditional air unit volume ('parcel') processes in the atmosphere layer from the surface of the earth to a standard isobaric level of 100hPa. It also considers relief forms and local features influencing storm activity, e.g. the character of the spreading surface, water objects and others.

Hydrodynamic forecast method for the energy industry

The adiabatic process in saturated air is the basis for the model. Pressure and temperature in a wet adiabatic process are expressed by the formula of a wet adiabatic curve. While condensation remains in a liquid phase, this formula takes the following form (the formula for adiabatic curve condensation):

$$\frac{dT}{T} = \frac{AR_d}{c_p}\beta\frac{dp}{p} = 0{,}285\beta\frac{dp}{p}$$

$$\beta = \frac{p+a}{p+b};\ a = 0{,}623\frac{LE}{ART};$$

$$b = 0{,}263\times\frac{\mathrm{L}}{\mathrm{c_p}}\times\frac{dE}{dT}$$

where:
T = air temperature, K;
A = thermal equivalent of work, equal to 1/427kcal/klm;
L = specific capacity of transition of water steam in water;
Rd = specific gas constant of dry air;
Cp = specific thermal capacity of air under constant pressure;
p = atmospheric pressure, hPa;
E = pressure of saturated water stream, hPa.

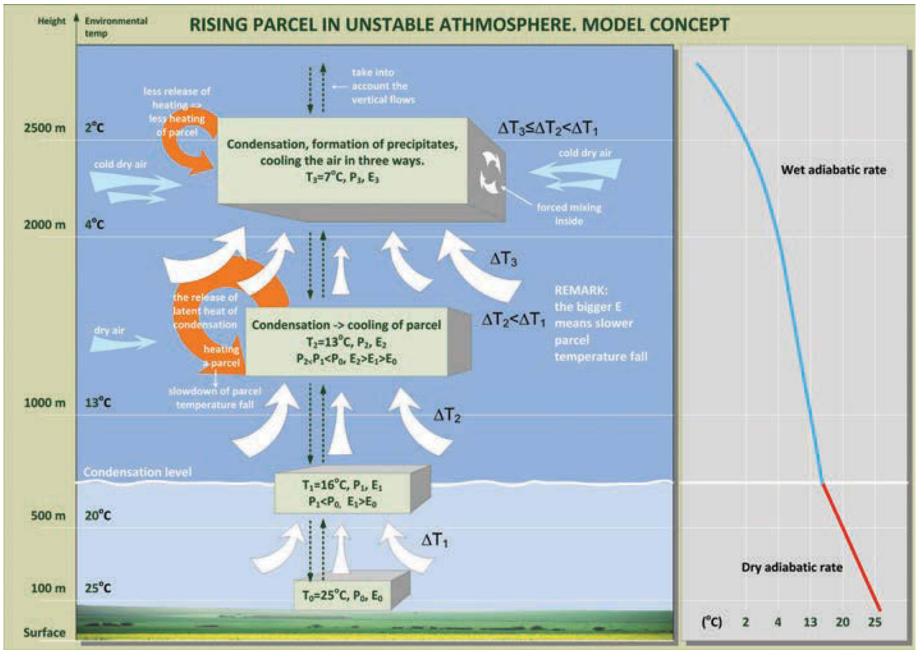
Practice shows that a forecast calculated only on the basis of adiabatic processes or other techniques isn't exact or reliable. On this basis it is impossible to determine the exact time of the origin of a thunderstorm, lightning activity, the spatial position of the centers and their movement.

The developed model for thunderstorm forecasts is understood on the basis of many parameters that minimize errors, and the calculation is carried out in a number of stages:

- Assimilation and initial processing of entrance predictive data for hydrodynamic models, with a warning time of up to 120 hours;
- Parameter calculation of the air mass, which can cause thermodynamic instability in the ground layer and the free atmosphere;
- Calculation of condensation level – height of spreading surface and sea level;
- Calculation of convection parameters in a dry adiabatic process;
- Calculation of convection parameters in a moist adiabatic process, taking into consideration the effect of air involvement;
- Calculation of the origin of thermodynamic instability in the free atmosphere without the influence of the surface layer warming up.

Comparison of obtained data with a predictor of thunderstorm formation

Predictive data of any hydrodynamic or meso/large-scale model can serve as initial data. The model gives the minimum



temperature at the upper limit of overcast, the height of convective overcast, the thermodynamic parameters in a cloud, and the speed of ascending currents.

In practice the application of this method gives high-precision predictions of the origin, development and dissipation of storm centers in time and space, and also the influence of wind shift on the dynamics of development and the destruction of storm clouds.

Research into the field of numerical forecasting of the quantity and intensity of convective precipitation, lightning activity on the earth's surface (density and distributions of lightning discharges on the area), hail, squalls and tornadoes, is currently being conducted. However, there are some problems that need to be solved.

Problems of method realization

The first problem is predictive data errors of hydrodynamic models on temperature and humidity distribution in the ground layer and at heights, which sometimes degrade the quality of the forecast.

This problem was solved by adapting a convective overcast development algorithm on the basis of the consideration of systematic predictive data errors. Parameter changes of air mass under the influence of convective movements that substantially increase errors in the hydrodynamic models predictive data also have a negative impact on the storm forecast.

But the main problem is with forecasts of thermodynamic characteristics of storm clouds. They do not allow sufficient prediction of lightning activity, in particular lightning character, its spatial distribution (in-cloud or cloud-to-ground), cloud movements, and also the dangerous phenomena that accompany thunderstorms, such as a strong precipitation, hail, squalls and tornadoes.

These academic problems should be solved by the study of storm cloud thermodynamics, including the application of the latest methods of atmosphere sounding. This technique uses several pilotless aircraft with high-precision sensors, including temperature, pressure, humidity, intensity of electric field, and an ultrasonic sensor to measure the size of hydrometeors (water drops, hailstones and ice crystals).

Research will enable the further study into atmospheric storm parameters – ascending and descending flows, thermodynamic cloud characteristics and the spatial distribution of volume charges, and also the influence of atmospheric processes on movement and development dynamics.

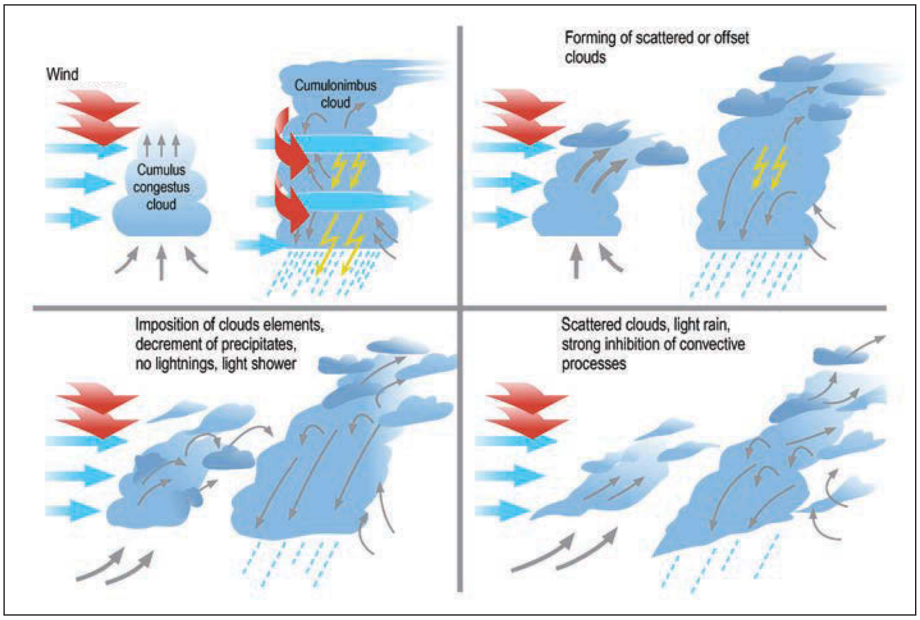
The complexity involved in using pilotless aircraft lies in the fact that the aircraft have to be strong and the sensors have to be reliable, to withstand wind, lightning, frost and hail. A further consideration is the limited ceiling of the pilotless aircraft as storm clouds can develop at heights up to 18km, which not every apparatus can reach. In this case, other methods of sounding are used with the help of radio sounders and meteorological locators.

It is only after studying storm atmosphere parameters in detail that it is possible to estimate objectively the physical processes within clouds and predict all dangerous phenomena qualitatively.

Continued study

Detailed studying of these processes will enable the industry to create qualitative predictive models of convective phenomena, which in turn will enable the qualitatively prediction of thunderstorms, the development and movement dynamics of single cells and multicells, and the formation of super cells. ∎

Roman Stepanov and Alexander Lukin are both meteorologists with NAMOS, based in Moscow, Russia



by Steve Marley and Jack Hayes

STAYING GROUNDED

Enhanced severe weather forecasting at the time of GOES-R

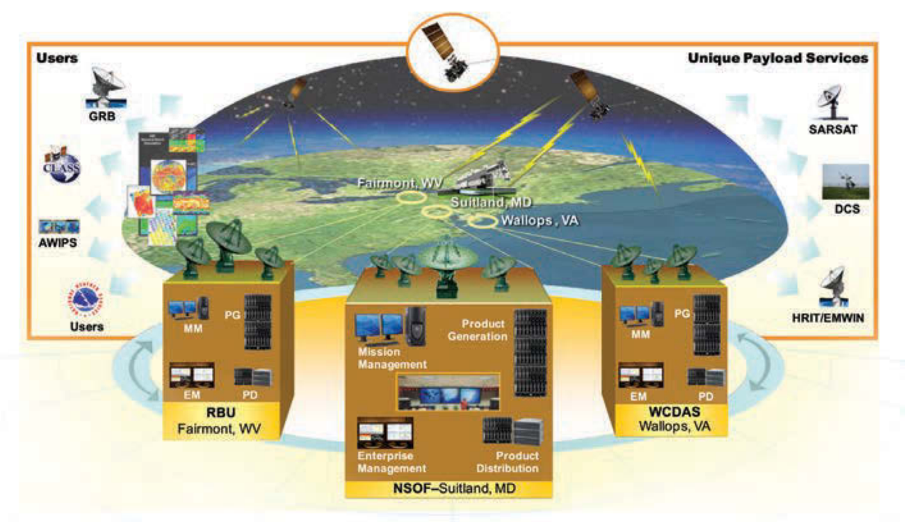
As the next generation of geostationary environment satellites reaches a critical time, with launch due in 2015, one company is responsible for the ground segment of the project

It's mid-afternoon in tornado alley, USA. The weather forecast offices of the National Weather Service Southern Region have been on edge all day. Trained tornado spotters have been deployed since mid-morning. The numerical models indicate that it might be an active day. There's warm, moist air at the ground and a front of cold dry air moving in from the northwest. The sky has been clear all morning but conditions are perfect for an outbreak of severe storms and possibly a tornado or two.

As the afternoon progresses forecasters pay close attention to the imagery from NOAA's brand-new Geostationary Operational Environmental Satellite (GOES), which is providing high-resolution observations every five minutes. The expected thermal lifting and the characteristic overshooting cloud tops begin to form, alerting forecasters to monitor weather radars.

As conditions worsen, NOAA's severe weather assets shift into high gear and severe storm watches are upgraded to warnings. The command is given to switch the GOES Advanced Baseline Imager into Rapid Scan mode, providing updates every 30 seconds over a 1,000 x 1,000km box covering the active weather region.

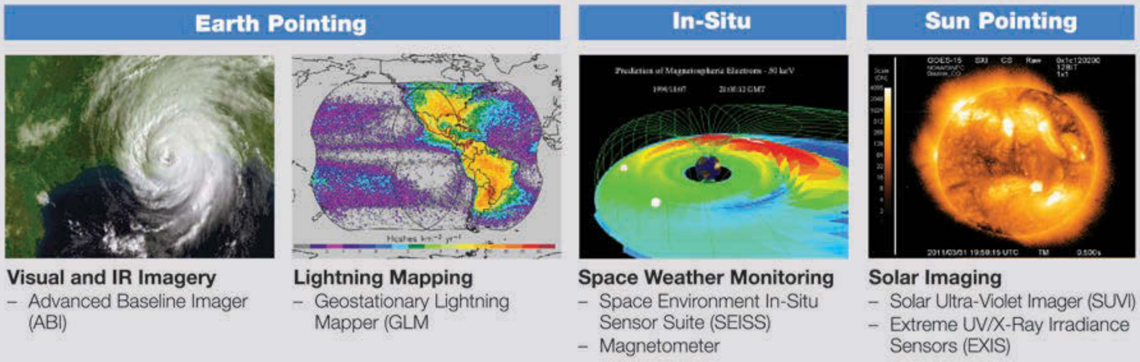
Advanced ground radars are focused on likely altitude and direction for tornadogenesis, and forecasters begin to look for the tell-tale signs of a rotating mesocyclone several miles high inside the storm. A sudden surge of cloud-to-cloud lightning is detected by the Geostationary



The GOES system graphically laid out in its entirety

Above: New NOAA Satellite Operations Facility in Suitland, Maryland, USA (Picture: NOAA)

Right and left: GPM Precipitation Science Research Facility at Wallops Flight Facility



GOES-R instruments suite

Lightning Mapper aboard GOES. This is a key indicator of potentially tornadic conditions and the local weather forecast office issues tornado warnings. Twenty minutes later the first confirmed tornado touchdown is reported. By early evening it is clear that this was a good day. The additional advanced warning window afforded by the instruments on the new GOES platform, together with information from NOAA's sophisticated network of weather sensors, enabled forecasters to detect the threat and issue timely tornado warnings and, more importantly, alerted people to find shelter and ride out the worst of the storm.

Respond time

The ability to prepare for and respond to severe weather events requires the effective coordination of many federal, state and local agencies. Central to this effort is the timely availability of accurate relevant and actionable information.

The Geostationary Operational Environmental Satellite – R Series (GOES-R) is the next generation of National Oceanic and Atmospheric Administration (NOAA) geostationary Earth-observing systems. GOES-R greatly improves on the current instrument complement and ground system technology and will provide a revolutionary step forward for severe weather detection, forecast and warning (above).

The Advanced Baseline Imager (ABI) will observe the western hemisphere in 16 visible, near-infrared and infrared bands at 0.5, 1 and 2km respectively. The ABI will scan the entire continental USA every five minutes and, during severe weather outbreaks, smaller mesoscale regions as often as every 30 seconds. In addition the ABI scans the entire full disk every five minutes (every 15 minutes during severe weather operations).

The Geostationary Lightning Mapper (GLM) will provide 10km resolution day and night coverage of cloud-to-cloud and cloud-to-ground lightning activity with a latency of 20 seconds or less. Also, monitoring of potentially dangerous solar storm activities that could threaten US energy distribution infrastructure is achieved through a suite of sun pointing and in-situ instruments.

Satellite data

In addition to being able to provide more frequent and higher resolution observations, the enhanced instrument suite on GOES-R will be able to deliver new data products. In addition to the ability to monitor severe thunderstorms and detect lightning, the product set (left) that NOAA is developing for implementation in the ground segment will make major contributions in a number of key areas vital to the protection of life and property:

• Hurricane forecasting and tracking – improving the accuracy of forecast intensity, water content and landfall prediction;
• Fire monitoring – locating fires and monitoring pre- and post-burn conditions to help firefighters, communities and emergency managers to better prepare for and respond to fire dangers;
• Air quality – monitoring hazardous sources and events and providing early warnings of air quality risks to the public, environment and aviation;
• Coastal and marine monitoring – improved observations of marine environments and sea surface temperature will provide more accurate and timely hazard warnings;
• Precipitation and floods – improved storm location and rainfall rate information will result in more timely and accurate flash flood watches and warnings;
• Land cover – improved frequency of multiband higher-resolution imagery will provide more detailed, cloud-free views to discriminate surface features such as drought conditions, flooding and crop health;
• Volcanoes – improved detection of ash

Baseline Products

Advanced Baseline Imager (ABI)
Aerosol Detection (Including Smoke and Dust)
Aerosol Optical Depth (AOD)
Clear Sky Masks
Cloud and Moisture Imagery
Cloud Optical Depth
Cloud Particle Size Distribution
Cloud Top Height
Cloud Top Phase
Cloud Top Pressure
Cloud Top Temperature
Derived Motion Winds
Derived Stability Indices
Downward Shortwave Radiation: Surface
Fire/Hot Spot Characterization
Hurricane Intensity Estimation
Land Surface Temperature (Skin)
Legacy Vertical Moisture Profile
Legacy Vertical Temperature Profile
Radiances
Rainfall Rate/QPE
Reflected Shortwave Radiation: TOA
Sea Surface Temperature (Skin)
Snow Cover
Total Precipitable Water
Volcanic Ash: Detection and Height

Geostationary Lightning Mapper (GLM)
Lightning Detection: Events, Groups, and Flashes

Space Environment In-Situ Suite (SEISS)
Energetic Heavy Ions
Magnetospheric Electrons and Protons: Low Energy
Magnetospheric Electrons: Medium and High Energy
Magnetospheric Protons: Medium and High Energy
Solar and Galactic Protons

Magnetometer (MAG)
Geomagnetic Field

Extreme Ultraviolet and X-Ray Irradiance Suite (EXIS)
Solar Flux: EUV
Solar Flux: X-Ray Irradiance

Solar Ultraviolet Imager (SUVI)
Solar imagery (X-Ray): Coronal holes, solar flares, coronal mass ejection source regions

Future Capabilities

Advanced Baseline Imager (ABI)
Absorbed Shortwave Radiation: Surface
Aerosol Particle Size
Aircraft Icing Threat
Cloud Ice Water Path
Cloud Layers/Heights
Cloud Liquid Water
Cloud Type
Convective Initiation
Currents
Currents: Offshore
Downward Longwave Radiation: Surface
Enhanced "V"/Overshooting Top Detection
Flood/Standing Water
Ice Cover
Low Cloud and Fog
Ozone Total
Probability of Rainfall
Rainfall Potential
Sea and Lake Ice: Age
Sea and Lake Ice: Concentration
Sea and Lake Ice: Motion
Snow Depth (Over Plains)
SO_2 Detection
Surface Albedo
Surface Emissivity
Tropopause Folding Turbulence Prediction
Upward Longwave Radiation: Surface
Upward Longwave Radiation: TOA
Vegetation Fraction: Green
Vegetation Index
Visibility

GOES-R product list

clouds, sulfur dioxide and other emissions will lead to improved volcano hazard warnings;
• Aircraft icing – accurately identifying icing threats will reduce delays and improve flight planning and hazard advisories;
• Low cloud and fog – enhanced monitoring of fog conditions and low cloud cover will improve safety and reduce costs on the ground and in the air.

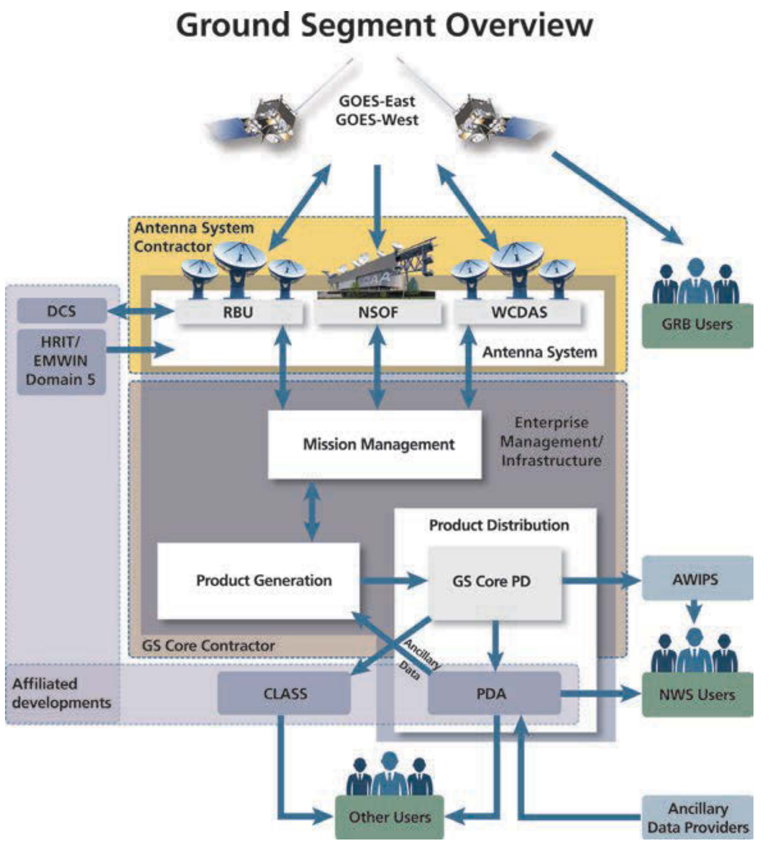
Ground segment

Expansion of the observational capabilities of GOES-R is reflected in an increase in ground-segment performance. As the prime company for the GOES-R ground segment, Harris is responsible for delivering the end-to-end solution for the management of the satellites and payload, antenna and data downlink processing, as well as rebroadcast and information distribution (see right). In many respects the ground-segment architecture for GOES-R is very similar to that of its predecessors.

Raw observations are downlinked to the Wallops Command and Data Acquisition (WCDAS) in Wallops, Virginia, where it undergoes radiometric and geometric calibration processing. The resulting recovered radiances are then packaged for rebroadcasting and sent back to the satellite for acquisition by the Direct Readout community. As with earlier GOES missions, the NOAA Satellite Operations Facility (NSOF) in Suitland, Maryland, is one of those users. The NSOF takes the Level 1b downlink and derives the environmental variables from which end users can in turn derive actionable information. However, the consistency of the GOES-R ground architecture with earlier generations disguises some key differences that end users will see:
• Data volume. Driven by the enhanced capability of the ABI, the GOES-R ground segment generates considerably more data at higher resolution and much greater frequency;
• Product latency. The increased volume has to be delivered near real time for many products ;
• System reliability. Expected data outage is reduced from more than 300 hours per year for the current system to under three hours per year for GOES-R.

In addition, to these external changes, internally the GOES-R system is being built to the latest high standards of cyber security consistent with its status as a national infrastructure asset.

These high performance goals, required the development of a next generation processing architecture capable of handling the simultaneous operations of two operational geostationary satellites (one in an easterly position and one in a westerly) in a highly reliable and secure implementation.



GOES-R ground segment

Direct Readout

Harris is also implementing operational tools to enable the effective quality monitoring of the product data stream, and has implemented an architecture that facilitates science integration and enables the transition of algorithms from research to operations.

For most users of GOES-R data, the greatest change, and the one requiring upfront investment, will be the Direct Readout solution. After GOES-R becomes fully operational, the current GOES Variable (GVAR) will be retired. The new GOES Re-Broadcast (GRB) represents a major technology upgrade for users who receive GOES data direct from the satellite.

Although the downlink is still in the traditional L-Band, the data rate is much higher and uses international data content and transmission standards. In addition, instead of the current linear polarized downlink, GRB uses a more efficient dual circular polarized approach. To receive Direct Readout from the GOES-R satellites, current GVAR users will need to upgrade their current systems, including the downlink system (a 4-5m dish is recommended for most users), the data format interpreter, and back-end data management and processing. In order to support end-users in this transition, Harris has developed a number of transportable GRB simulators that emulate the GOES-R GRB downlink. They are available by request through the NOAA GOES-R program office.

The GOES-R mission will make substantial improvements to NOAA's forecasting and severe weather nowcasting capabilities and will provide valuable contributions to public safety across the western hemisphere. Ground-segment design and development is on track to meet the launch and initial operations. Harris is investing to evolve its ground system into the enterprise solution capable of meeting all NOAA's satellite ground processing needs for years to come. ∎

Steve Marley is chief engineer for R&D, Weather Products & Services, Harris Corporation, USA. Jack Hayes is vice president Weather Products & Services, Harris Corporation

by Matt Wright

FROZEN POTENTIAL

The ability to predict snow water equivalent is essential

Increasing global demand on water resources, and the importance of predictive risk management, highlights the need for accurate snow water equivalent measurements

Photos are courtesy of Centre for Hydrology, University of Saskatchewan. Photographed by Angus Duncan

Snow melt is a large source of fresh water in many areas of the world, making its measurement an important source of information for the management of water resources. Snow water equivalent (SWE) is the measurement of how much water is present within a snowpack. In order to make sound water management decisions, it is essential that SWE measurements be as effective and accurate as possible.

Although the concept of SWE is simple, achieving accuracy in its measurement can be very difficult. The ideal SWE measurement system would utilize a non-contact technique that would not affect the accumulation or wind distribution of snow. The system would not have the potential to cause environmental harm and would be easy to install or conduct. It would not modify the interactions of water, temperature or radiation between the atmosphere, snow and/or ground. For modeling and forecasting it is critical that SWE be measured continually to provide the peak SWE and thus an estimation of the maximum amount of water that will be available.

SWE measurement techniques

Common techniques that have been used to measure SWE include snow cores, snow pillows/snow scales, and precipitation gauges.

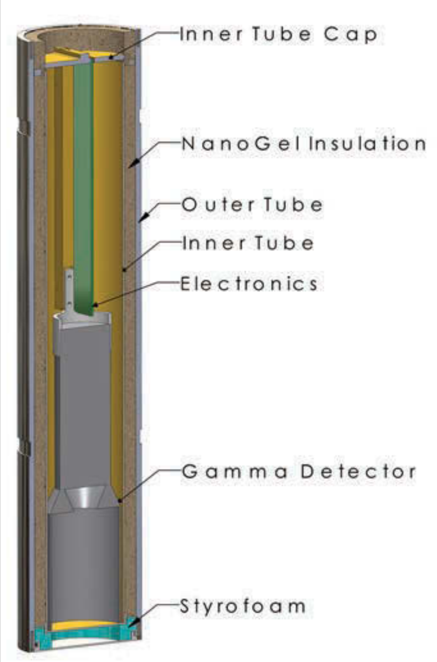
The snow core method involves removing and weighing a core of the snowpack to determine SWE. Measuring SWE using manual snow cores is a fairly reliable technique when measuring dry snowpacks; however, obtaining snow cores requires significant time and labor, making it an expensive method – particularly when conducted in remote areas. It is also a destructive procedure that is prone to human error and does not allow for the same parcel of snow to be measured twice. Under wet snow conditions it is very difficult to obtain accurate snow cores, and this often results in an underestimation of SWE. Snow cores also only provide point measurements and do not allow for continual monitoring of the same snowpack, making it difficult to determine peak SWE.

Snow pillows and snow scales are installed at ground level and use pressure transducers to measure the weight of snow as it accumulates to measure SWE. While this non-destructive technique allows for continual data monitoring and works well in snowpack conditions in which few freeze-thaw events occur over the winter, transport and installation of snow scales and pillows in remote areas can be difficult and expensive. Snow pillows often use a rubber bladder that is filled with glycol to prevent freezing and thus presents an environmental hazard. Both snow pillows and scales are susceptible to bridging, a situation in which ice lenses form in the snowpack and modify the distribution of weight, which results in measurement errors. The pillows and scales also form a barrier between the ground and the snowpack, resulting in a disturbance in the interaction of water and thermal heat between the two mediums. Dark pillows and scales can also absorb more solar radiation than the surrounding environment, potentially resulting in a delayed accumulation on the pillow in the autumn and increased melt rate in the spring.

Precipitation gauges, which collect rain and snow to measure year-round precipitation, can also be used to measure SWE. This method can provide a continuous SWE measurement if the precipitation change from rain to snow can be accurately determined. Again, like the snow cores, snow pillows and snow scales, using the precipitation gauge to measure SWE has its disadvantages; measuring SWE with a precipitation gauge is intrusive as it collects and melts the snow to determine its water equivalent. Errors in SWE measurement can occur due to increased windspeeds, which impact catch efficiency and snow capping on the top of the gauge. Precipitation gauges also cannot provide peak SWE, or SWE during the melt phase when the temperature rises above 0°C. Like snow pillows, they also pose an environmental hazard due to the glycol used to melt snow that has collected in the gauge. Maintenance for these gauges can also be expensive in remote locations as the water in the gauge must be emptied on a regular basis and the correct glycol-to-water ratio must be maintained to ensure the water does not freeze within the gauge.

A new technique to measure SWE

The CS725, developed by Hydro Québec in collaboration with Campbell Scientific Canada, is a gamma monitor that measures SWE. It passively measures the net natural terrestrial gamma radiation emitted by the soil after the radiation is absorbed by the snowpack. The CS725 is a non-contact sensor that is installed well above the maximum snowpack height and provides a measurement of SWE and soil moisture four times a day for a selected site, allowing for unattended monitoring in near real time. The sensor element utilizes a thallium doped sodium iodide crystal NaI(Tl) to measure naturally emitted terrestrial gamma radiation. It detects potassium (40K) and thallium (208Tl) gamma particles (the most abundant naturally emitted gamma rays) and places counts of each gamma ray detected in a histogram. This histogram is used to calculate SWE with the measurement accuracy proportional to the square root of measurement time. The precise measurement of SWE is calculated by detecting the attenuation of naturally occurring gamma rays by the snow cover. As the snowpack accumulates, the CS725 measures a decrease in the gamma ray counts; the higher the water content, the higher the attenuation of the gamma rays.



Cross-section of the CS725 system

The CS725 measures SWE over a large surface area (50-100m^2 when mounted 3m above the ground), and provides a technique that is effective with any type of snow and ice. Its performance is not affected by adverse weather conditions or bridging. Once installed, the CS725 can be left in the field for seven years maintenance-free. However, the CS725 is presently limited to a maximum range of approximately 600mm of SWE and is dependent on a suitable amount of terrestrial gamma radiation. It must also be calibrated under snow-free conditions and requires known soil moisture at the time of ground freeze-up at the onset of winter.

Currently, the CS725 is in operational use or has been trialed in Alberta and Quebec (Canada), Anestølen (Norway), and Utah and New York (USA), with comparison to snow core measurements, snow pillow, snow scales and precipitation gauges. In all, Hydro Quebec has 17 sites in operation using the CS725 to measure SWE.

Comparison of different techniques

Field-testing of the CS725 was conducted at Sunshine Village, Alberta (2008-2011); SNOTEL Tony Grove Ranger Station, Utah (2009-2010); and Anestølen, Norway (2011-2012). Automated SWE measurements were made at the various test sites using the CS725, snow pillow and precipitation gauge. Monthly manual snow core measurements were also conducted at Sunshine Village (2009-2010) and Anestølen, Norway (2011-2012). Analysis of CS725 performance was conducted by comparing the SWE measurements of the CS725 to measurements taken by snow pillows, precipitation gauges, and manual snow core measurements at the three test sites.

As there is no standard method to precisely measure SWE values of a snowpack, assessment of SWE measurement techniques must therefore be conducted by examining errors associated with a particular technique and the scale of impact those errors have on usage of the sensor. When the CS725 was compared with the snow pillow and precipitation gauge at all test sites, all the methods demonstrated strong agreement (Figures 1-3); however, deviations between the different measurement techniques were observed at the three field sites for all seasons. Although many hypotheses can be formed to explain these deviations, there is no way to determine the true causes without detailed snow surveys on a daily scale, which would result in destruction of the snowpack at the survey site.

CS725 SWE measurements demonstrated increased variability at greater snow depths (1.2-1.5m) for all seasons at Sunshine Village (Figure 2). However, this was not observed at the Tony Grove Ranger Station (Figure 1), nor at Anestølen, Norway (Figure 3), likely due to the lower maximum SWE and snow depth at each test site. This increased variability in the CS725 SWE measurement may be explained by a decrease in potassium counts as the SWE and snow depth increases, resulting in a greater possibility of noise (non-target sources of potassium gamma rays). Statistical comparisons of the three automated daily SWE measurements at all sites show strong correlations (0.96-0.99) between the CS725 and snow pillow and the CS725 and precipitation gauge. Due to this and the comparisons of the three techniques above, it is difficult to determine a significant difference between the measurement techniques.

This study reminds us of the present issues still faced with the measurement of SWE. Due to the various errors associated with each measurement technique, there is no single ideal method for measuring SWE, thus, in most situations the choice of measurement technique often comes down to cost. Depending on the period of time over which measurements are taken and when personnel, installation and transportation costs are taken into account, the CS725 can become cost-effective when compared with manual snow core measurements and other automated techniques for measuring SWE. The CS725 is unaffected by the majority of the disadvantages associated with snow cores, snow pillows and precipitation gauges as described above, while adding some advantages not provided by the other techniques. These advantages, along with the early but stable results of the CS725 evaluation, indicate it can be an effective solution to these long-standing measurement challenges. ∎

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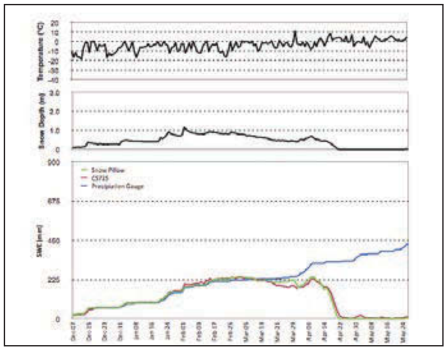

Figure 1: SNOTEL Tony Grove Ranger Station test site comparing SWE measurements from the CS725 (magenta), precipitation (blue) and snow pillow (green) from December 7, 2009

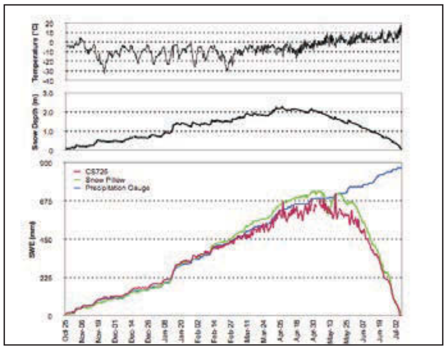

Figure 2: Sunshine Village test site comparing SWE measurements from the CS725 (magenta), precipitation gauge (blue) and snow pillow (green) from October 25, 2008

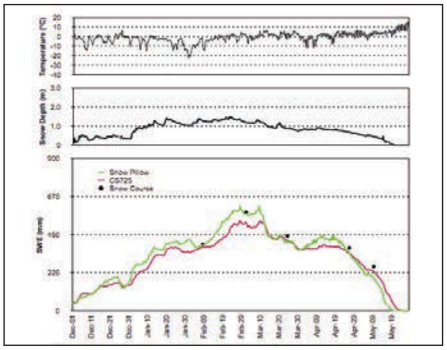

Figure 3: Anestølen test site comparing SWE measurements from the CS725 with collimator (magenta), CS725 without collimator (light blue), snow pillow (green) and snow core (black)

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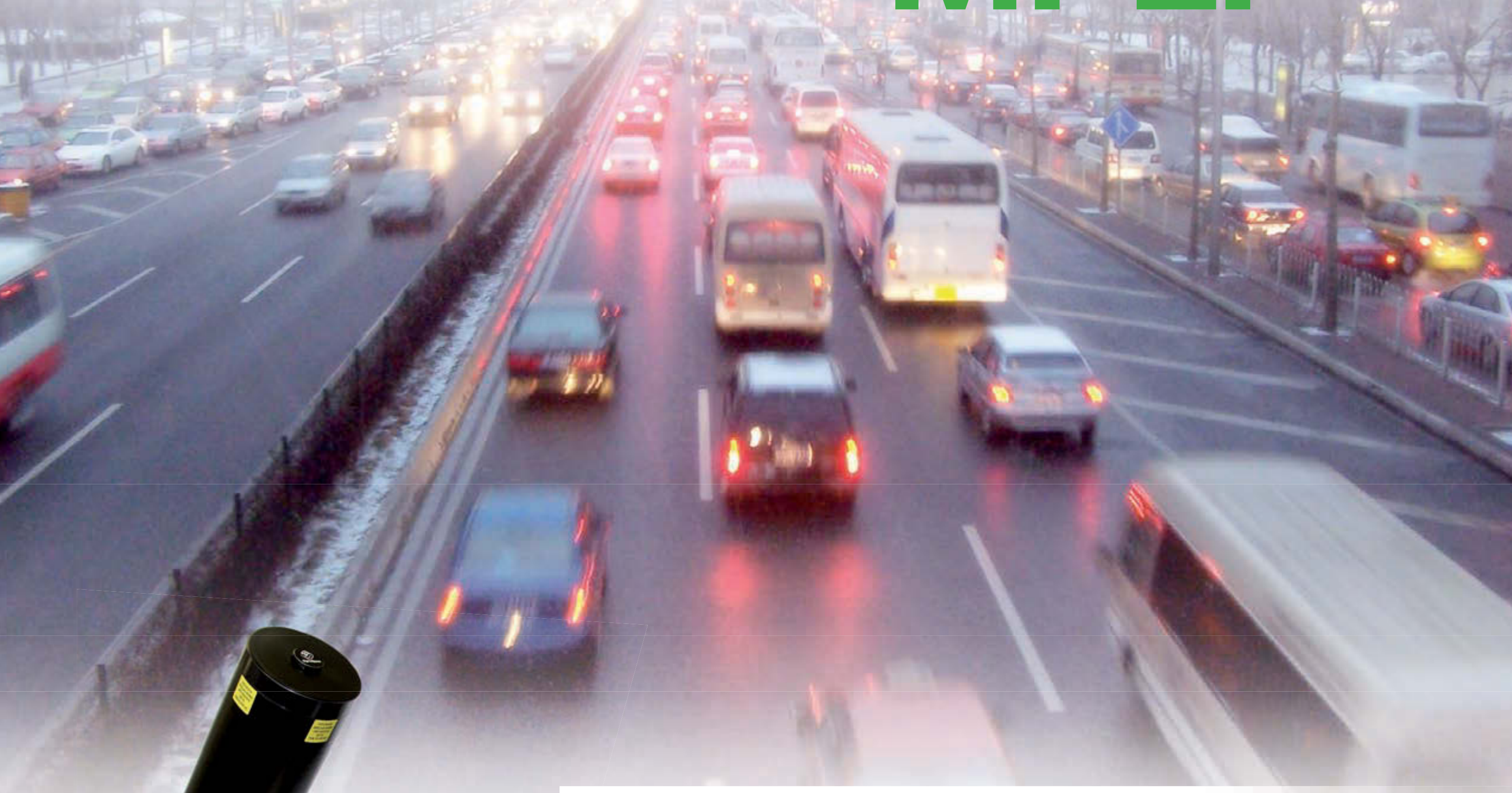

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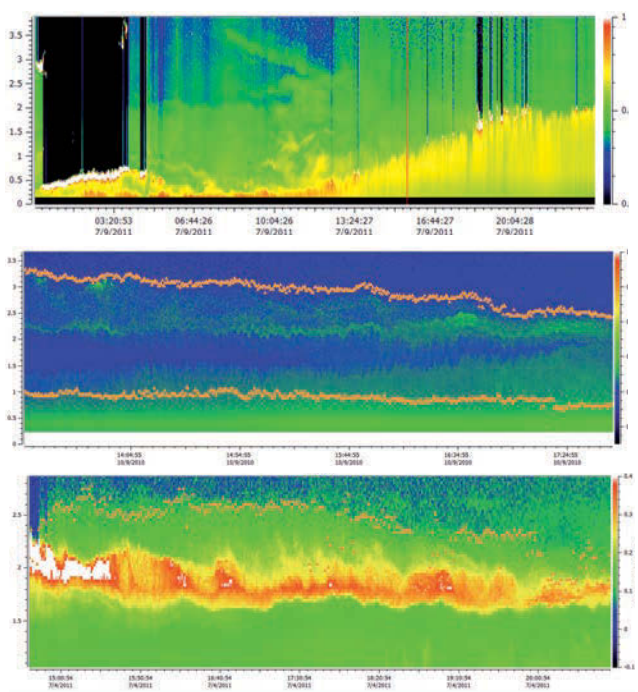

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EXCELLENCE IN AEROSPACE TECHNOLOGY

by William Lahoz

CITIZEN'S OBSERVATORY

Where does our air quality come from?

A personal and user-friendly excursion into what determines air quality and what you can do to inform yourself about it

You are interested in the quality of the air where you live – the 'air quality', often identified as 'AQ'. Good air quality is desirable, you wish for no harmful substances in the air composition – you want to live in a healthy environment. For example, you would be interested in knowing the amount of ozone in the air, as it could affect your lungs; you might be interested in the amount of pollen in the air – the pollen count – as it could affect your allergies. So you ask what affects the air composition where you are located – what affects your air quality?

Thinking about this issue, and having some knowledge of what determines air composition, you consider that two elements contribute to the air quality where you are located: chemical interactions involving substances in the air above and around you; and emissions of substances from the surface where you live – for example, from industry. You recognize this and feel safe because you live in a remote part of the world where the air above and around you is clean, and therefore you think there are likely to be few substances to be involved in chemical interactions; and you know that where you live there is little or no industry to emit substances that could be harmful. But you are a scientist, and this is not enough, so you make a measurement of the air composition where you live with an instrument you borrow from your friend from the measuring station up the road. And you are surprised to find a number of potentially harmful substances are detected in significant amounts in the air, including ozone and aerosols such as particulate matter. What went wrong? How could this happen?

Long-range transport

What went wrong is that you forgot that air moves from one place to another, and that this air can carry potentially harmful substances from far away to where you are located. And even if local conditions provide good air quality, conditions far away may not. The local conditions where you live could not prevent this air with potentially harmful substances from reaching you. The process that you overlooked is called long-range transport (Figure 1), and it is the third element that contributes to the air quality where you are located.

You now know that three elements contribute to the air quality where you are located: chemical interactions; emissions; and long-range transport. These are described in studies by, for example, HTAP (2007)[1] and D J Jacob (2000).[2] But again, you are a scientist and would like to know more details about the air quality where you are located. In particular, you would like to know the concentration of potentially harmful substances, and how this concentration evolves in space and time. The air quality may be good today, but will it be good tomorrow? The air quality may be good today where you are, but it may not be good at a location near you, and long-range transport could bring this bad air quality to you tomorrow.

Observational gaps

To understand how you can determine the concentration of substances contributing to air quality, you recognize you must take account of a key characteristic of observational information, namely that it has gaps in space and time (Figure 2). You also recognize that these gaps depend on the nature of the observation – for example, if the observation is made remotely from a satellite in space, or if the observation is made in situ on the ground. Do these observational gaps matter for air quality? They do in at least two ways: first, you may wish to know the air composition at gaps in the observational information; and second, you may wish to derive extra information from the observations that requires this information be provided on a uniform grid. In both cases you need to fill in the gaps in the observational information. How could you do this? You could assume the observations are constant; you could interpolate linearly between the observations; or you could do something more sophisticated. In all cases you are using a model of how the observational information behaves to fill in the observational gaps. You realize you need a model to fill in these gaps.

Choosing a model

The choice of model complexity is up to you, but this choice could depend on what you need to know, and how you want to know this. The model could be very simple, or very complex; for example, it could include chemical reactions, emissions and transport processes. Also, the model information, which is available at places other than where you are located, needs to be evaluated – one would commonly do this by comparison with observations. So you also need observations not just where you are, but at other locations, to evaluate the model. Finally, you realize that to make sense of a comparison between the model and observations and, in fact, to make use of the information from the observations and the model, you need to know the uncertainty associated with this information. This uncertainty will tell you how much trust you should place in the observations and/or the model. And this will help you make informed decisions in response to the air quality information at your disposal. For example, if you have an allergy and the pollen count is high, you should consider staying indoors.

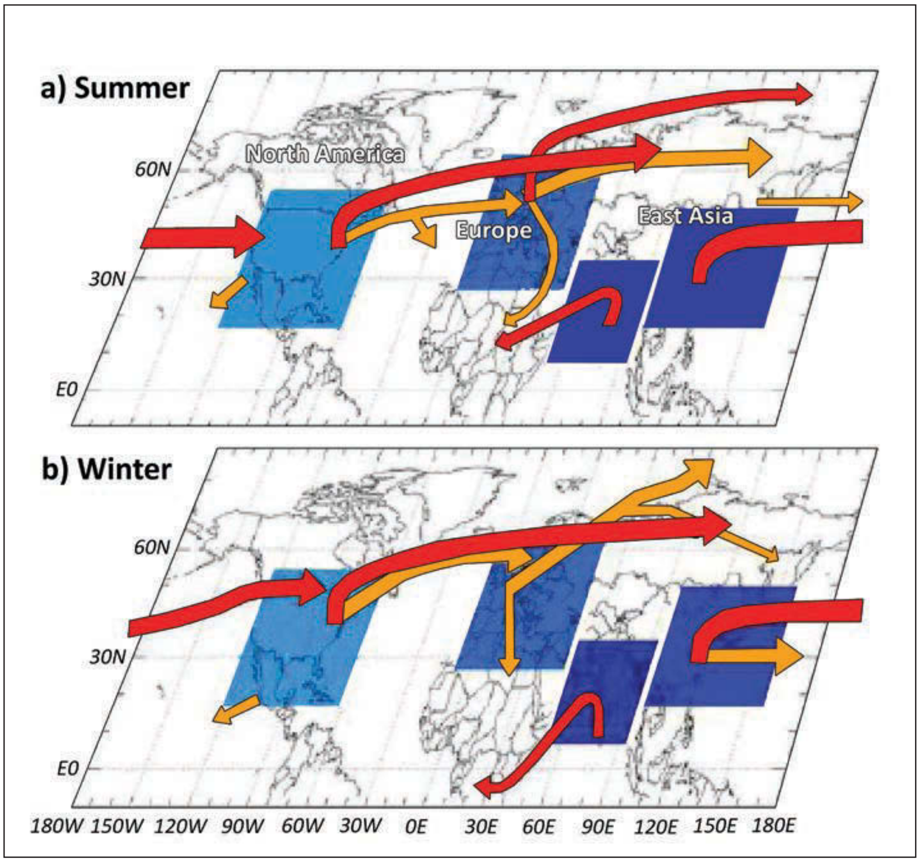

Figure 1: Plot representing intercontinental transport pathways in the Northern Hemisphere. Arrows approximate the magnitude of these pathways for summer (June/July/August, panel a, top) and winter (December/January/February, panel b, bottom). Orange arrows indicate transport near the surface (altitudes less than 3km); red arrows indicate transport higher in the atmosphere (altitudes greater than 3km). The boxes indicate regions used in model studies to study this transport. Plot based on material from HTAP (2007)

Data assimilation

But the model information need not be considered on its own to fill in the observational gaps. For example, you could combine it with observational information in an objective manner, including its uncertainties, to fill in these gaps. And this is already done – this is "data assimilation", a subject on which there is considerable literature, in particular with respect to weather forecasting.[3,4] This approach is also used for air quality forecasting. [5,8]

The data assimilation procedure produces a data set called an "analysis". An attractive feature of the analysis is that it "adds value" to the observational and model information. To the former, it adds value by filling in the observational gaps; to the latter, it adds value by constraining it with observational information. This added value is reflected objectively in that, provided the observational and model information are well characterized, including their errors, the information content of the analysis is higher than that of the observational and the model information separately.[4] So the information provided by the analysis is likely to be more useful than the observational or model information separately.

The analysis produced by data assimilation can be used as the initial conditions of, for example, the state of the atmosphere, for a weather forecast using a model. Similarly, it can be used for an air quality forecast. The more accurate these initial conditions, the more accurate the forecast is likely to be. So it is important to use the observational and model information in the best way possible, and a lot of effort is spent by the meteorological agencies to determine the best possible initial conditions of the state of the atmosphere.[3]

The observations that provide information on where air comes from, and which you could use to provide an air quality forecast, and also to evaluate the model that provides information on where air comes from, have to be placed at suitable locations. This is important when both local (chemical interactions and emissions) and remote (long-range transport) factors affect the air composition, and thus the air quality, at your location. Identifying these locations is useful, but may be difficult to do objectively. How do you determine the best locations? You could use both the information from the model and from the observations. And this is already done using data assimilation ideas by the

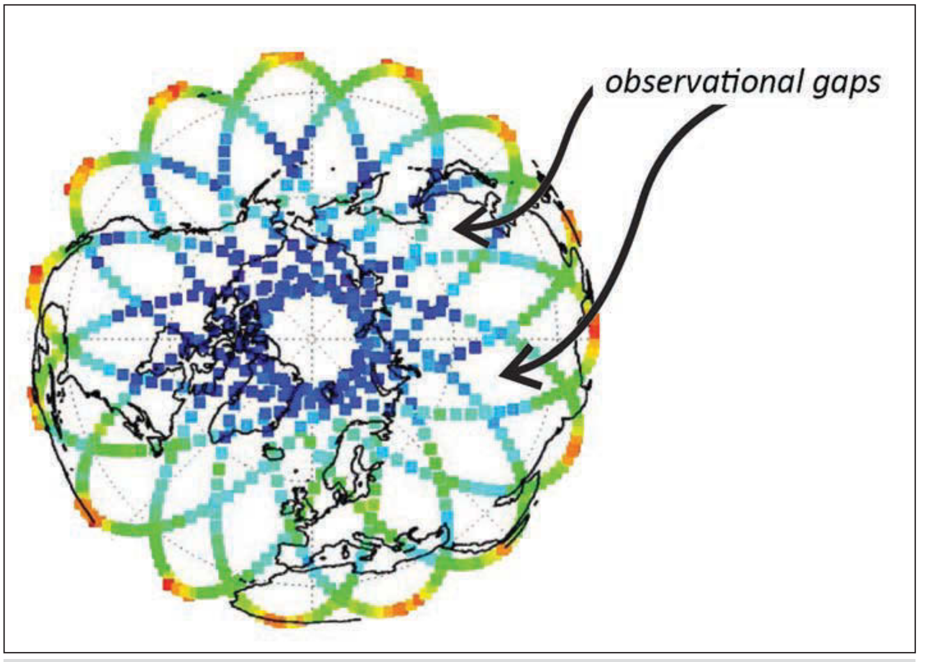

Figure 2: Plot representing ozone data at 10hPa (approximately 30km in altitude) showing the observational geometry of measurements from a limb-viewing satellite. Blue denotes relatively low ozone values; red denotes relatively high ozone values. The measurements are typical of Northern Hemisphere winter, showing relatively low ozone values in the Arctic region. Note the gaps between the satellite orbits. Plot based on material in Lahoz et al. (2010)

meteorological agencies and the space agencies to assess where to locate future observations, and to design an observational network. This network could be used, for example, to monitor air quality and assess if regulations (for example, from the European Commission) are being complied with. The approach is called an observation system simulation experiment (OSSE).[6,7]

Work by NILU

You now know that observational and model information combined and/or on their own, is useful to: provide air quality information locally; take account of local and remote factors affecting air quality; provide the initial conditions for an air quality forecast; and help design an observational network to monitor air quality. NILU Norwegian Institute for Air Research scientists are working on all these aspects of the research into improving our knowledge of atmospheric composition and how this affects air quality.

Once you recognize that the level of information you are interested in is often required at a very local level – for example, where you live, or the street where you walk – you also recognize the possibility of you being the observation platform, you being a citizen's observatory. For this you would need to be able to receive and transmit information on the air composition where you are located. And there is a ubiquitous observational platform that has this potential use: the mobile phone. The potential of this platform has been recognized by the European Commission, notably by funding a number of EU-wide projects, including the CITI-SENSE project, which is coordinated by NILU (http://citi-sense.nilu.no). This project was described at the European Commission Green Week held in Brussels in June 2013 (http://greenweek2013.eu/).

In recognizing which factors affect air composition, and thus air quality, and that we can obtain information on air quality from observations and models, and their combination, we have come full circle: from recognition that air quality affects you, and that both local and remote factors contribute to air quality, to the recognition that you can be the observational platform that both provides information about air quality and receives information about air quality. This empowers you, the citizen's observatory. ∎

References

1) HTAP, 2007: Hemispheric Transport of Air Pollution 2007. ECE, EB.AIR/94 (http://www.htap.org)

2) D J Jacob, 2000: Heterogeneous Chemistry and Tropospheric Ozone. Atmos. Env., 34, 2131, 2159

3) E Kalnay, 2002: Atmospheric Modeling, Data Assimilation and Predictability. Cambridge University Press, Cambridge, UK, p341

4) W A Lahoz, B Khattatov and R Ménard (Eds.), 2010: Data Assimilation: Making Sense of Observations. Springer, p718

5) W A Lahoz, V-H Peuch, J Orphal, J-L Attié, K Chance, X Liu, D Edwards, H Elbern, J-M Flaud, M Claeyman and L El Amraoui, 2012: Monitoring Air Quality From Space: The Case for the Geostationary Platform. Bull. Amer. Meteorol. Soc., doi: 10.1175/BAMS-D-11-00045.1, 221-233

6) M Masutani, J S Woollen, S J Lord, G D Emmitt, T J Kleespies, S A Wood, S Greco, H Sun, J Terry, V Kapoor, R Treadon and K A Campana, 2010a: Observing System Simulation Experiments at the National Centers for Environmental Prediction. J. Geophys. Res., 115, D07101, doi:10.1029/2009JD012528

7) M Masutani, T W Schlatter, R M Errico, A Stoffelen, E Andersson, W Lahoz, J S Woollen, G D Emmitt, L-P Riishøjgaard and S J Lord, 2010b: Observing System Simulation Experiments. Data Assimilation: Making Sense of Observations, W A Lahoz, B Khattatov and R Ménard, Eds., Springer, 647-679

8) L Rouïl, C Honoré, R Vautard, M Beekmann, B Bessagnet, L Malherbe, F Meleux, A Dufour, C Elichegaray, J-M Flaud, L Menut, D Martin, A Peuch, V-H Peuch and N Poisson, 2009: PREV'AIR: An Operational Forecasting and Mapping System for Air Quality in Europe. Bull. Amer. Meteor. Soc., 90, 73-83

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by Yoshiaki Takechi

DOPPLER SYSTEM

3D compact X-band weather radar system for urban areas

A look at an experiment using a new 3D weather radar system installed around Kobe city in Japan

Extreme weather in Japan has caused disasters across urban areas. Rainfall intensity can exceed 50mm/hour, caused by cumulonimbus clouds that develop rapidly in areas as small as 10km to a few dozen kilometer in radius.

In urban areas of Japan, X-band weather radar systems that are capable of observing rainfall more precisely are in the process of being deployed by the government. This is in addition to conventional large C-band weather radar systems. However, the conventional C-band radar system takes approximately five minutes to conduct a three-dimensional observation of rainfall, leaving a problem for real-time data provision required for city residents to act quickly.

Also, with the popularity of walking navigation systems on smartphones, it is now possible to inform users about evacuation routes by which they can avoid heavy rain or severe thunderstorm. As such, Furuno experimentally developed the compact X-band dual-polarimetric doppler weather radar, which analyzes the vertical structure of cumulonimbus clouds.

As well as the compact X-band doppler weather radar, which detects the movement of rain clouds in high space-time resolution, the company developed and verified a multifunction radar system that consists of the above mentioned two types of radar with integrated scanning ability. The aim was to put into practical use a radar system for an urban area that can output information that enables navigation, along with rainfall prediction.

This article provides an interim report on the experiment of the 3D Compact X-Band Weather Radar System installed around Kobe city.

Figure 1: Installation image of a monitoring site

Approach

In order to conduct observations in an urban area (20km radius range) in high space-time resolution, Furuno developed prototypes of weather radar that can easily be installed on the roofs of buildings. The installation images of the prototypes on a monitoring site are shown in figure 1.

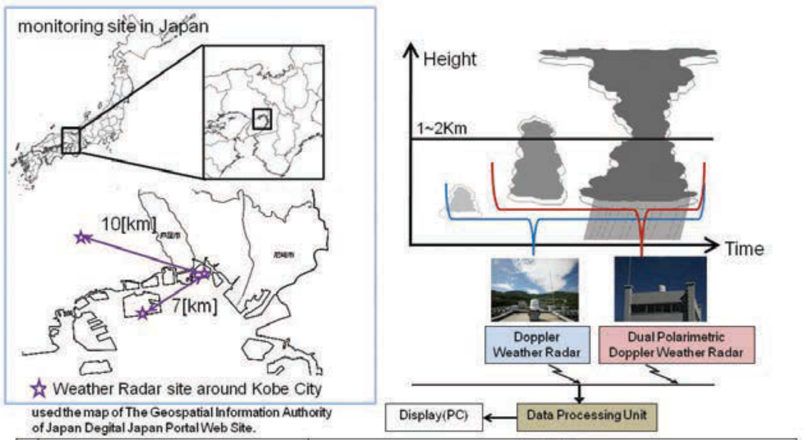
The compact X-band dual-polarimetric doppler weather radar has been designed to be the world's smallest, both in size and weight. The main unit (weighing about 65kg) can be divided into three parts that can be carried and installed by users without using cranes. All three parts can be carried into an elevator through doors no less than 82cm wide.

The radar system consists of two units of single-polarization doppler radar of horizontal polarization and one unit of dual-polarimetric doppler radar. The single-polarization doppler radar can detect and track rain clouds and observe their movement. The dual-polarization doppler radar implements the range height indicator (RHI) sector scan mode at high speed, cutting through the clouds to observe their internal structure.

Unlike the large weather radar, which observes rain clouds from mountain tops, the proposed system makes 3D observation on cumulonimbus clouds by looking up at them from a low point on the ground, shortening the detection distance to increase the information update frequency to 30 seconds.

The system lowers the network load by combining the dual-polarization doppler radar, which handles large amounts of data, with the data processing unit (DPU) and connecting the single-polarization doppler radar, which handles small amounts of data, via the network.

The observation data from the three weather radar units is collected into the DPU, which outputs the information to facilitate rainfall prediction navigation in real time. The DPU runs the short-time rainfall prediction algorithm at the hardware level. The 3D compact X-band weather radar system is shown in figure 2.



	hardware	function
1	Compact X-band Doppler Weather Radar	Precipitation intensity and Doppler velocity can be detected.
2	Compact X-Band Dual Polarimetric Doppler Weather Radar	In addition to above functions, 3D distribution of precipitation and shape of water particles can be measured.
3	Data Processing Unit	The precipitation intensity and Doppler velocity from each radar site can be integrated/merged and converted into 3D data. Short-time (near future) precipitation can be predicted.

Figure 2: 3D compact X-band weather radar system

Observations result

The spiral scan (multi-elevation plan position indicator – PPI) mode using the dual-polarization doppler radar is shown in figure 3, the single PPI scan mode in figure 4 and the RHI scan mode in figure 5. The spiral scan mode begins from an elevation angle of 2°; the PPI scan mode is conducted on rainfall approximately 30km or farther away by scanning one circle in six seconds; and the RHI scan mode, for obtaining vertical cross-section scans up to a 90° angle of elevation, takes five second.

The horizontal wind vector estimated using doppler velocity at a distance of 30km at approximately 10m/sec is shown in figure 6, the detailed results observed by doppler radar in figure 7, and accumulated rainfall for one hour – about 8mm – in figure 8.

Based on the results, the company came to the conclusion that it was able to conduct high-precision observation of 150m resolution (equivalent to a pulse width of 1μs). The rainfall composite map results from two units of the single-polarization doppler radar are shown in figure 9.

Furuno has decided to combine the precipitation data by using the dual-polarization radar together with the single-polarization radar. The company has generated a sample of real-time 3D images of precipitation, based on the high-precision 3D observation data (figure 10) and the rainfall prediction navigation image, which would enable users to avoid localized short-term rainfall (figure 11).

Furthermore, in order to facilitate high-speed data processing for real-time observation, which is the aim of this system, the bottleneck in the overall algorithm – the processing of dual-polarization data to short-time rainfall prediction – must be resolved quickly.

The research team ported a software program for data processing, which had already been developed on a PC, so that it could be executed on the field-programmable gate array. This hardware-based data-processing system proved to be best suited for algorithm verification that required trial-and-error methods, as in weather forecasting, and it enabled the team to tune the real-time system efficiently.

Future perspectives

Experiments and evaluation to deliver maximum performance are to be conducted with the minimum configuration of two single-polarization doppler radars and one dual-polarization doppler radar, by concerted observation in summer when cumulonimbus clouds develop locally and cause sudden torrential rainfall in Japan.

In addition, there are various ideas for

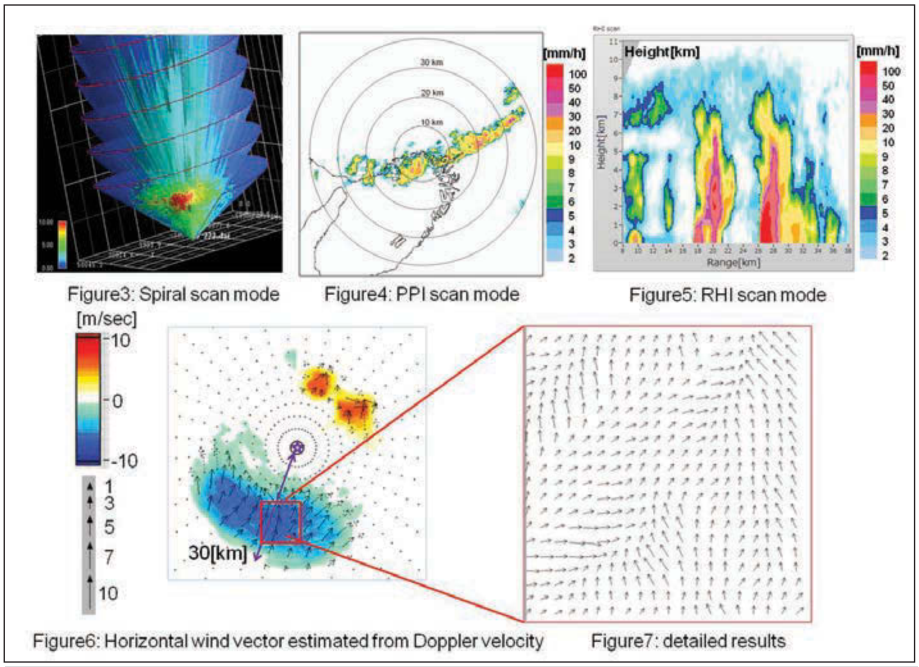
> "While the information obtained will be mostly used for citizens' benefit, it could also be used for disaster prevention"

the integrated operation of the 3D compact X-band weather radar system to enable the weather to be observed more quickly and precisely. The company aims to use the system to help study short-term rainfall prediction, tornado observation and so on, in cooperation with universities and research institutes.

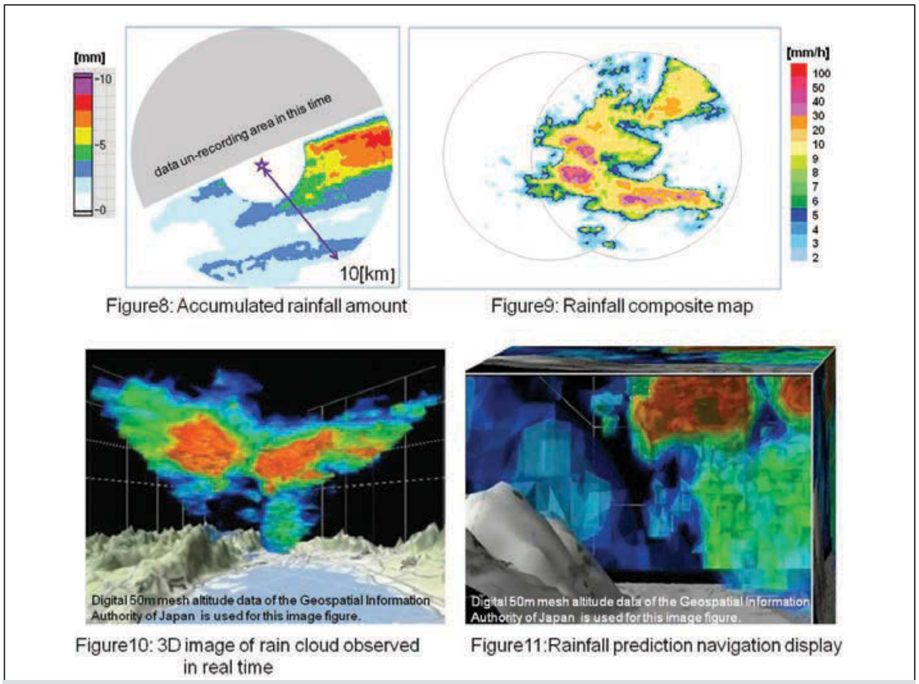
Project goal

The goal is to establish a base technology that can provide high-frequency rainfall prediction information with high temporal resolution at 30-second intervals in an urban region over a radius of approximately 20km. While the information obtained through this base technology will be mostly used for citizens' benefit, it could also be used as information for disaster prevention in times of localized short-term rainfall, giving information about evacuation routes as well as hazard area avoidance. This can be done by overlaying the information gathered by the system on a hazard map for flooding, landslides, storm surges and so on.

Furthermore, it is envisaged that high-precision rainfall prediction can facilitate support for decision-making navigation such as for travelling from school to home, or the office to the station, without getting soaked by rain, giving advice on taking shelter, using safe public transport and so on. It may also support the decision-making process in avoiding rivers or roads that tend to be flooded, by displaying the amount of accumulated rainfall on the map. ∎



Figures 3-7: Spiral scan mode; PPI scan mode; RHI scan mode; horizontal wind vector estimated from Doppler velocity; and detailed results (from Doppler velocity)



Figures 8-11: Accumulated rainfall amount; rainfall composite map; 3D image of rain cloud observed in real time; and the rainfall prediction navigation display

Yoshiaki Takechi is a chief engineer from Furuno Electric Co Ltd in Japan. The research is supported by JST's Adaptable and Seamless Technology Transfer Program through target-driven R&D. The research project is supervised by Professor Satoru Oishi at the Research Center for Urban Safety and Security

Primary Research Areas

Climate Research
Ozone-layer Depletion and UV Radiation
Long-range Transport of Air Pollution
Chemicals and Their Effects

Atmospheric Composition
Health-effect Studies
Urban and Industrial Pollution
Ecology and Economics

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Solutions

AirQUIS is an air quality management system provided as a suite of IT-tools facilitating air quality monitoring, analyzing, modeling, forecasting and data dissemination. AirQUIS enables the decision makers to identify and understand the air quality situation in order to implementing necessary measures for reducing air pollution.

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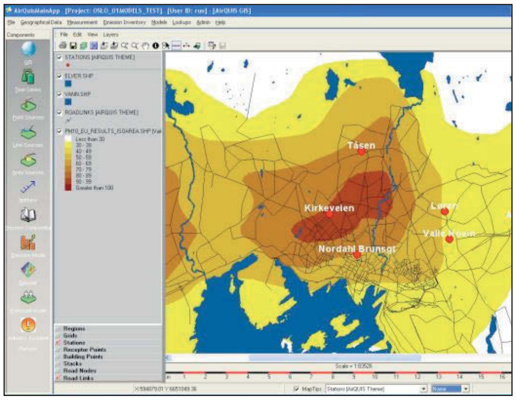

Luftkvalitet.info is a national air quality portal developed to provide real-time air quality information, forecasts and exceedances for major cities in Norway.

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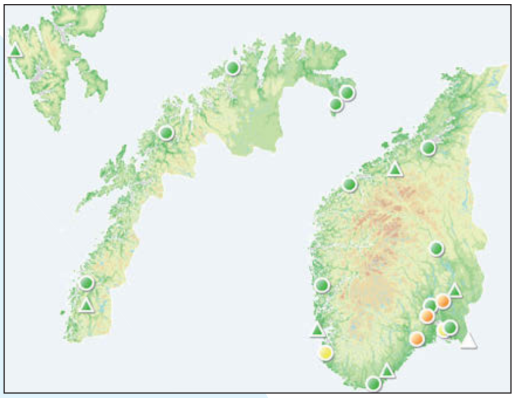

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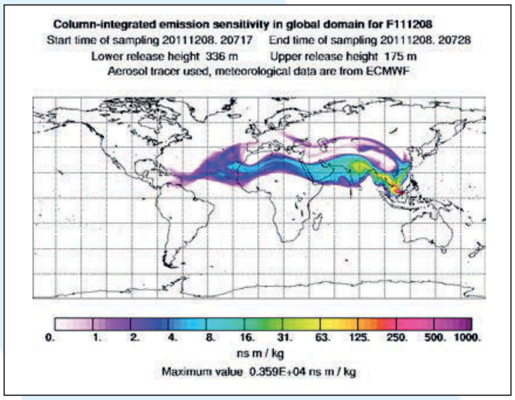

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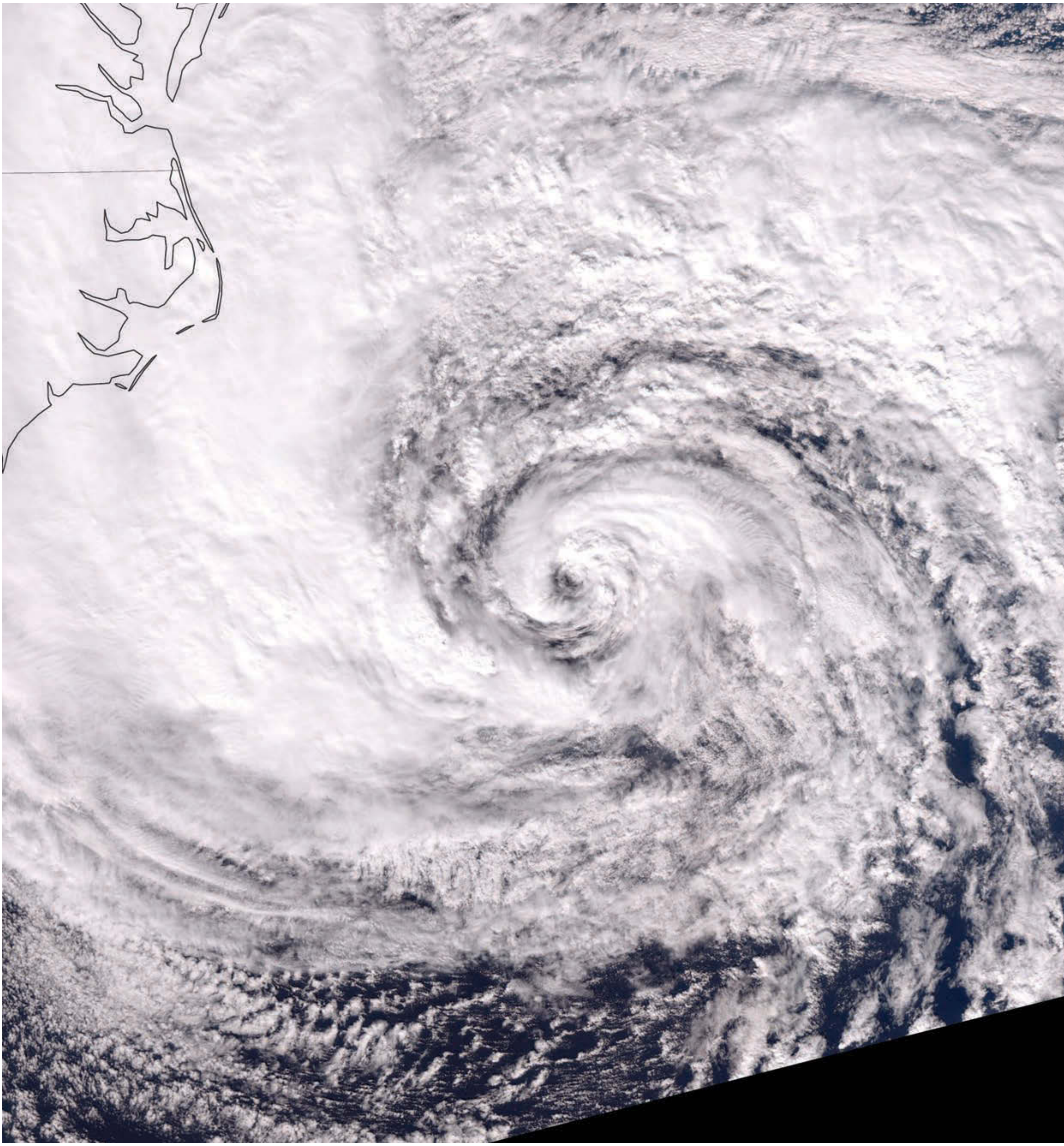
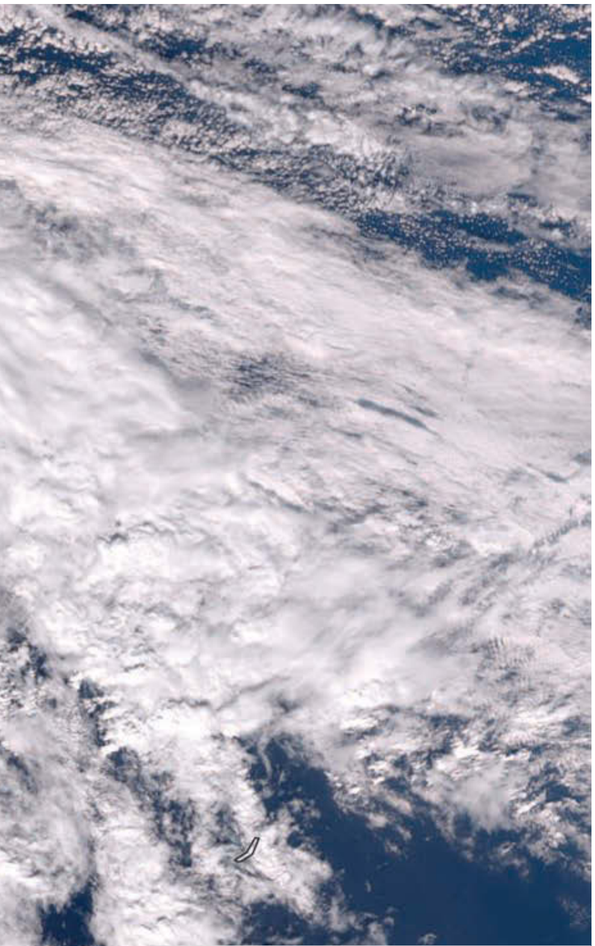
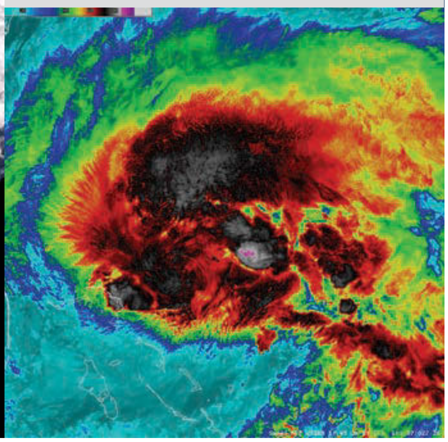
by Jeffery J Puschell







An infrared false-color image taken on October 26, 2012 (below), emphasizes the high clouds and upper-level outflow near Tropical Sandy's center, while the high spatial resolutions of the VIIRS instrument permits the analysis of gravity waves propagating out from the center, as well as the overshooting tops of deep convective towers that confirm the predicted intensification of then Tropical Storm Sandy into a hurricane. The second is a true color image captured on October 28, 2012 as the eye of the storm approaches landfall (Photos: NOAA/NASA)

BETTER WEATHER AHEAD

A look at the future of global weather and climate forecasting

With Suomi NPP's Visible Infrared Imager Radiometer Suite, meteorologists are discovering a new tool for improving the accuracy of their predictions

For more than 50 years, the Earth has been observed from space using instruments on board dedicated environmental remote sensing satellites. These satellites have changed the world by providing continuous global observations that make it possible to anticipate severe weather events and provide more accurate routine weather forecasts, which in turn helps protect property, save lives and sustain economic productivity.

Since the first weather satellite, TIROS-1 (Television InfraRed Observation Satellite-1), launched in 1960, space-based sensing technology has improved from television cameras providing fuzzy images of cloud formations to visible-infrared spectroradiometers that provide highly detailed information about the Earth's atmosphere and surface. Measurements made possible by an emerging generation of new technology instruments are vital to understanding the complex connections across the planet driving weather, biological productivity and climate conditions.

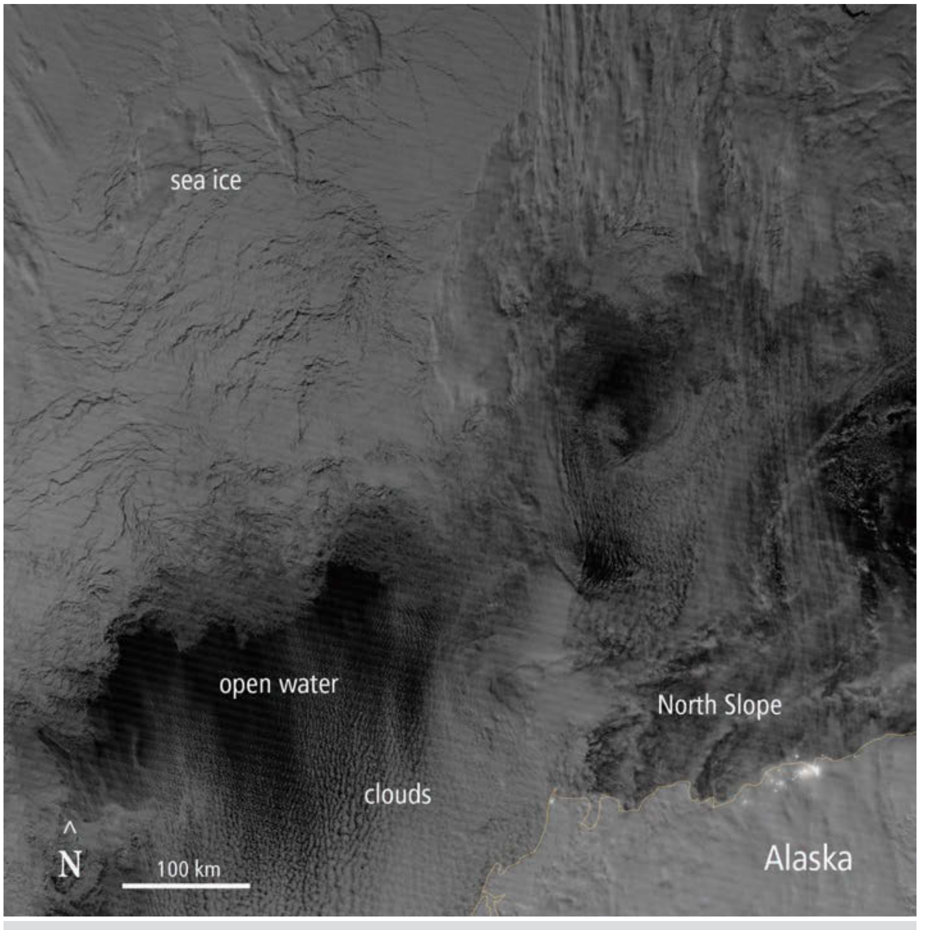
The NOAA/NASA Suomi National Polar-orbiting Partnership (Suomi NPP) satellite, launched in 2011, is the latest development in this 50 year-plus progression of systems that has revolutionized our perception and understanding of the Earth. Suomi NPP, named for Professor Verner Suomi of the University of Wisconsin, who flew the first space-based meteorological experiment in 1958, is the precursor to the Joint Polar Satellite System (JPSS), the next-generation operational polar-orbiting US system. JPSS replaces NOAA's Polar-orbiting Operational Environmental Satellite (POES) system, which traces its legacy back to TIROS, and the NASA Earth Observing System in orbit since the late 1990s. JPSS will operate as part of a constellation of polar-orbiting environmental satellites that also includes the current and next-generation EUMETSAT operational polar orbiting satellites and Defense Meteorological Satellite Program (DMSP) satellites.

A single instrument built by Raytheon, called the Visible Infrared Imager Radiometer Suite (VIIRS), is the primary source for 22 of the 38 environmental data products to be delivered by JPSS, directly contributing to weather and climate forecasting and monitoring of sea surface temperature, ocean color, land use, biomass fires, aerosols and cloud-top properties.

This next-generation sensor provides highly accurate and precise measurements of light radiated by the Earth at visible through thermal infrared wavelengths. Incorporating a modular, flexible design architecture, VIIRS capability can be adapted to future mission needs for the next 20 to 30 years, implementing lessons learned and responding to new requirements based on the existing, proven design.

Improving upon legacy technology

Beginning with the first flight unit (F1) aboard Suomi NPP, and continuing with future JPSS spacecraft, VIIRS replaces and improves on four sensors: the Moderate-resolution Imaging Spectroradiometer (MODIS), the Raytheon-built keystone of NASA's Earth Observing System, in flight



Monitoring the Arctic during 'polar darkness' with the VIIRS day-night band. (Photo: NASA)

since 1999; the Advanced Very High Resolution Radiometer (AVHRR), operating on board the NOAA Polar Operational Environmental satellites since 1978 and on the more recent EUMETSAT Meteorological Operational (MetOp) satellites; the operational line scanner (OLS), on board DMSP satellites since 1976; and the Sea-viewing Wide Field-of-view Sensor (SeaWiFS), also built by Raytheon, which provided ocean color measurements with unprecedented fidelity for more than 13 years aboard the Orbview-2 satellite.

VIIRS offers major breakthroughs in environmental remote sensing performance. Its 22 spectral bands provide four times better spectral coverage than AVHRR, thereby enabling new agricultural, climate, disaster monitoring, public health and weather data products. VIIRS also offers at least three times better spatial resolution than AVHRR and MODIS at end-of-scan, giving sharper imagery over a much greater area. A wider imaging swath (3,000km) eliminates coverage gaps at the equator during a single day of observation. A fully calibrated day/night band, with 100 times more sensitivity than OLS, improves night-time weather forecasting.

Innovative design

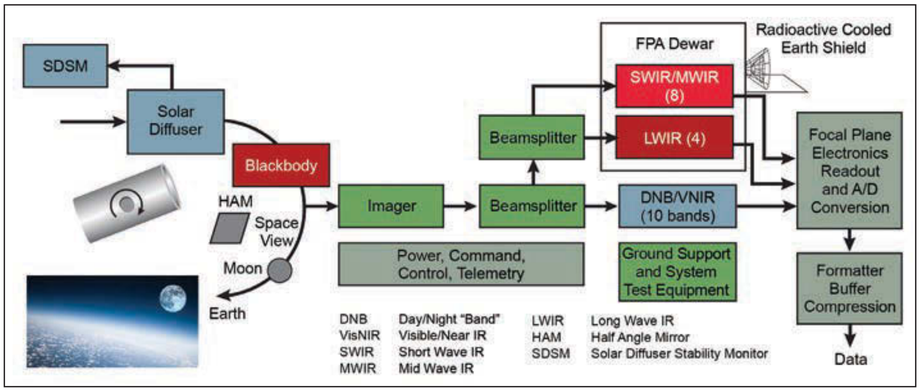
A key to the success of the VIIRS design is a rotating telescope assembly that can simultaneously meet a diverse set of requirements for multispectral imaging, spectroradiometry and low-light day/night observations. Advantages of the rotating telescope design relative to scan mirror-based systems include better control of stray light; smaller range in angle of incidence of light on the fore optics, to reduce image distortion; immunity to image rotation as the scan moves out from nadir; and better protection from contamination and degradation over time because all optical elements are deep inside the instrument housing.

The rotating telescope assembly is followed by a fixed telescope along with other back-end optics that image the scene and separate light onto three focal planes with filters that define each spectral band. A cryoradiator radiates heat from the infrared detector arrays to deep space to maintain a stable detector operating temperature as low as 78K.

The focal plane interface electronics carry signals from the detector arrays to the externally mounted electronics module (EM). The EM synchronizes the rotating telescope assembly with a rotating flat mirror to make it possible to image the scene onto the detector arrays without image rotation. The EM also provides onboard processing of detector samples to enable a nearly constant pixel size across the entire scan, data compression, processing of operational data, and formatting of the data into the Consultative Committee on Space Data Systems (CCSDS) format. The EM communicates via a databus with the spacecraft, to provide VIIRS operational data and telemetry, and to receive commands, spacecraft telemetry and software uploads. A fault-tolerant design enables long mission life.

VIIRS has an onboard calibration subsystem consisting of a carefully stabilized blackbody source to provide a reference signal for the emissive infrared bands, and a diffuser to provide a reference for bands dominated by reflected sunlight. VIIRS includes a monitor to detect any changes in the optical characteristics of the solar diffuser over time. The VIIRS calibration subsystem has a rich MODIS heritage – a key to maintaining continuity with data from the MODIS instruments onboard the NASA Earth Observing System Terra and Aqua satellites.

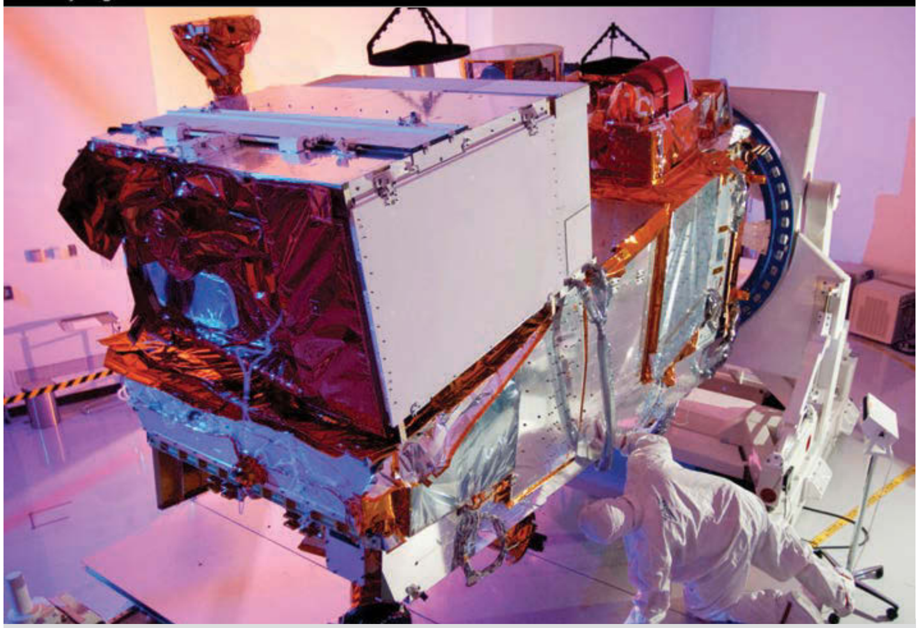
The two images on the opening page show two views of Hurricane Sandy. The first, on the left, is an infrared false-color image taken on October 26, 2012, emphasizes the high clouds and upper-level outflow near the storm's center. The high spatial resolution of the VIIRS instrument permits the analysis of gravity waves propagating from the center, as well as the overshooting tops of deep convective towers that confirm the predicted intensification of the then tropical storm into a hurricane. The



VIIRS architecture, from photon collection to data generation

Flight Units 1 and 2 Instrument Specifications

Orbit:	833 km polar sun-synchronous
Swath:	>3,000 km (±56 degrees about nadir)
Scanning:	Rotating telescope with dual-sided, half-angle mirror
Size:	135 x 148 x 89 cm^3
Spectral Coverage:	0.4 to 12.5 µm
Number of Bands	
Visible/Near Infrared:	9, plus day/night band (Pan)
Mid-wave Infrared:	8
Long-wave Infrared:	4
Resolution:	
Radiometric (16 bands):	0.742 km nadir, 1.6 km EOS
Imaging (5 bands):	0.371 km nadir, 0.8 km EOS
Day/Night band:	0.742 km constant across scan



VIIRS F1 and F2 instrument characteristics with image of F1 integrated onto the Suomi NPP spacecraft (Picture: Ball Aerospace)

second figure (on the right) is a true-color image captured on October 28, 2012 as the eye of the storm approached landfall.

Results show the VIIRS sensor validates its fundamental design architecture by delivering environmental data products with unprecedented completeness.

Night vision

One advance that has received particular attention is the VIIRS day-night band (DNB), a wide dynamic range, panchromatic spectral band that collects useful visible wavelength imagery with illumination ranging from full sunlight down to air glow and aurorae. It is sensitive enough to pick up light from single ships at sea at night.

Meteorologists in Alaska are finding VIIRS DNB imagery to be an important new tool for operational weather forecasting. The DNB is remarkably useful for characterizing clouds, detecting snow, ice and fog, and tracking hazardous weather patterns during the long Alaskan winter, when visible wavelength imagery from other systems is severely limited. Likewise, weather forecasters in the contiguous USA and elsewhere are finding that VIIRS DNB data enables clear views of weather events throughout the night, improving prediction accuracy.

As VIIRS F1 continues to perform well on board Suomi NPP, providing high-quality visible/infrared imaging spectroradiometry with unprecedented clarity and completeness, F2 is being built at Raytheon's facility in El Segundo, California. The sensor is on track for delivery in 2014 and a scheduled launch on board the first JPSS satellite in 2017.

As AVHRR and MODIS take their place in the history of space-based environmental remote sensing, VIIRS will continue to expand the record of environmental data that scientists use to understand the Earth, enhance weather forecasting and track climate conditions for future generations. ∎

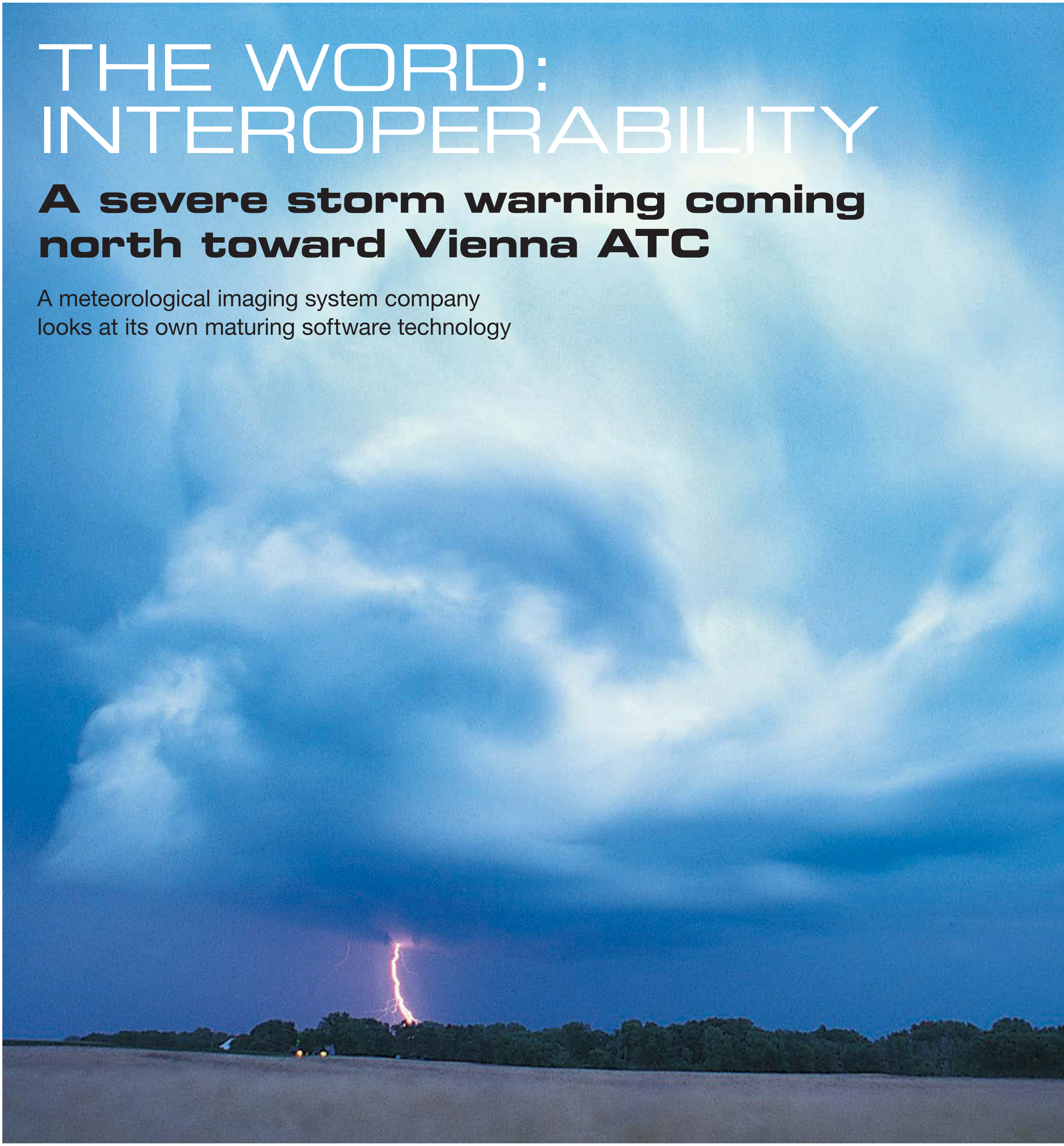
Jeffery J Puschell is the principal engineering fellow at Raytheon Space and Airborne Systems, based in the USA

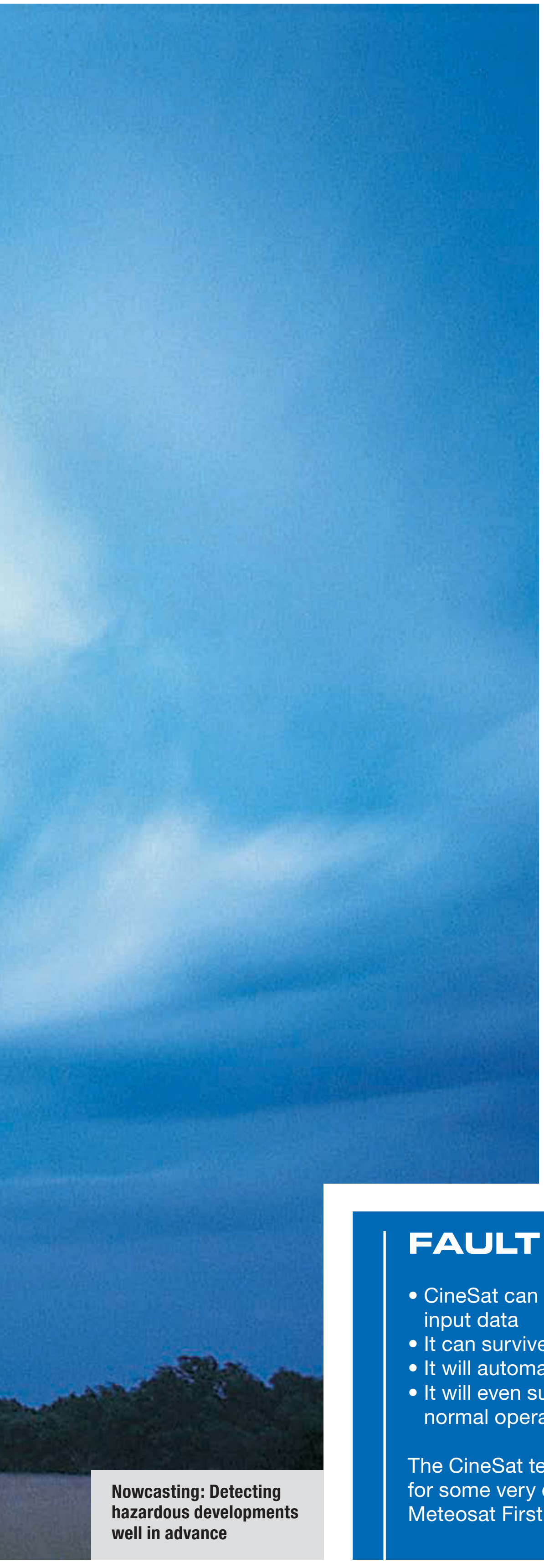
by Brigitte Scheiber

THE WORD: INTEROPERABILITY

A severe storm warning coming north toward Vienna ATC

A meteorological imaging system company looks at its own maturing software technology





Nowcasting: Detecting hazardous developments well in advance

At Meteorological World Expo 2012 in Brussels, CineSat's developers presented plans and achievements for new levels of interoperability. And one year later, the same company is keen to know how it is progressing along this road and is seeking user feedback and forecaster experiences to help in this.

CineSat is a fully featured meteorological imaging system covering all aspects of processing images from current weather satellites and merging them with other meteorological data to create highly informative weather products.

A special feature of the system is its unique set of automated real-time nowcasting tools, including cloud motion and development analysis; CB analysis and prediction of future movement; and predicted satellite images several hours into the future.

Bringing safety to aviation

Weather is still one of the main causes of air traffic accidents, and real-time short-range weather prediction adds extra safety in an ever denser airspace. Air traffic control authorities have reported that CineSat helped to prevent critical situations and enabled scheduled flights to fly safely in situations where other forecast data failed to reflect the actual situation.

FAULT TOLERANCE

- CineSat can handle missing, corrupted and delayed input data
- It can survive full-disk and network failures
- It will automatically recover from accidental process kills
- It will even survive power outage, and smoothly resume normal operation after power-on

The CineSat team installed automated, failsafe features for some very demanding operational solutions in the Meteosat First Generation Ground Segment, 1990-1995.

ATC weather service in Vienna

The Austrian ATC met office studied a six-day period with severe weather and pessimistic forecasts. A supercell with severe storms and rainfall was moving toward Albania and northern Greece.

Based on other forecasts, several flights would have had to be cancelled, resulting in delays and unexpected costs for the airlines.

This was the case with flight OS851 from VIE to LATI. For the destination of LATI, CineSat showed that the supercell would have passed the destination area by about 09:30am, and that this flight could be operated on schedule.

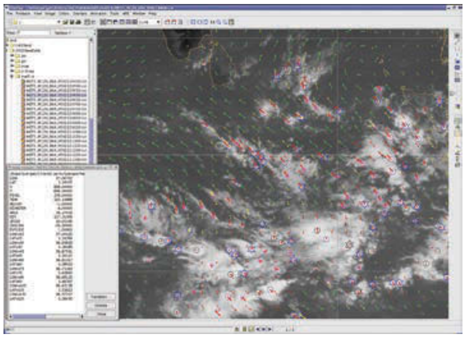
For flight OS881 to LGTS, a decision was needed on whether the supercell would move over northern Greece. CineSat analysis for the next few hours showed an interesting split in the atmospheric flow and, in contrast with numerical weather predictions, that the cell would not move east-south-east, but would progress on the northern branch of the stream in a north-easterly direction. This was contrary to NWP model forecasts and enabled a safe flight on schedule.

For flight OS831 to LQSA, forecasters were asked if the runway would be wet or dry at 10:30am as, for this type of plane, a wet runway would have been too short for landing. CineSat showed that the cloud system was decaying and that the chance of rain showers, as indicated by the Terminal Area Forecasts, was no longer a given.

In another case, an airline had asked about sending a transport plane with degraded de-icing facilities to UKKK. CineSat forecast images to show that a front with cold cell tops would stay in this area at the time of arrival, and in contrast to SigCharts, the company had to warn the pilots of some slight or medium icing on approach.

Breaking boundaries between weather services

Weather as a borderless worldwide process should be a seamless operation between



Cloud cell analysis and prediction over the Indian ocean (Photo: EUMETSAT)

meteorological systems. But while interoperability saves cost and improves services, in practice it does not always happen. For many weather services, it is still a challenge to obtain and correctly use data from another department.

CineSat's system architecture is especially designed to support close cooperation and exchange of data, procedures and methods between partners.

With dozens of data interfaces and a wide-ranging set of fast and accurate transformations, the system allows for a very smooth exchange of data between weather services.

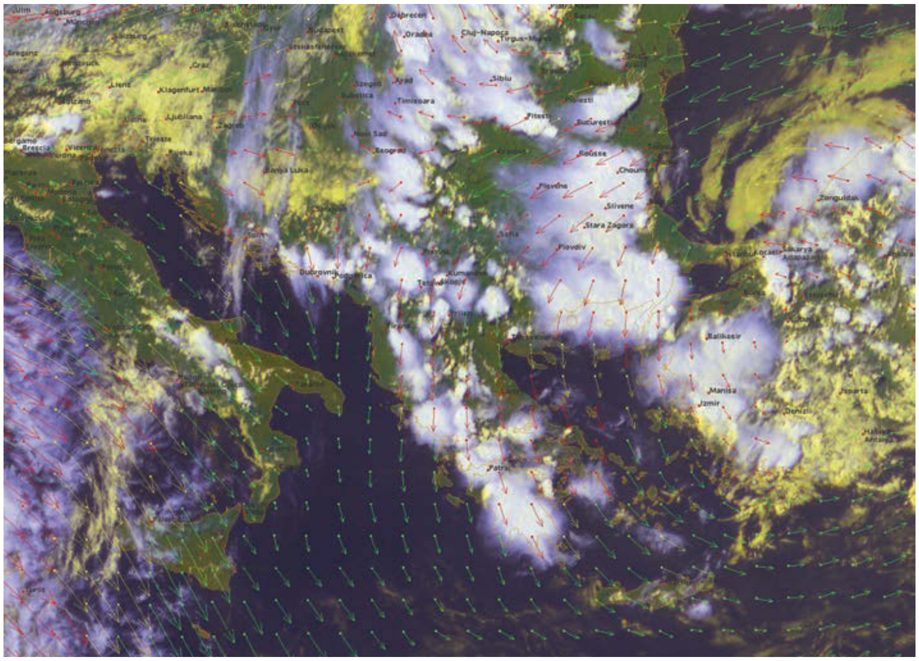
Interoperability, flexibility and integration

Most weather services require a very high level of interoperability between CineSat and their other systems. The company integrates into an existing environment that can be fully tailored to the needs of different applications.

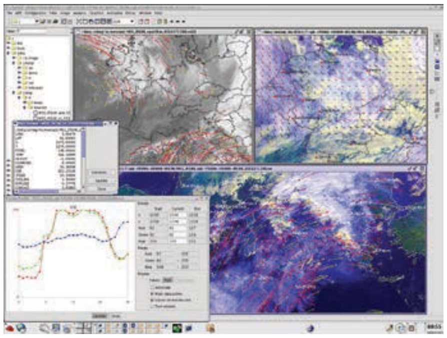
Users have full control over every single algorithm and production parameter, and can add their own processing. All configuration is stored in hierarchical profiles, which allow setting of company and group defaults, and quick creation of variants and research testbeds.

CineSat can be set up as a main data processing and display system, or act invisibly in the background to provide other systems and programs with data sets, images, tables, nowcasts, weather graphics and animation movies.

Several national weather centers use CineSat as a main production workhorse for all their imaging applications, calling their own programs and applications from its automation framework. Others integrate CineSat components into their own systems – such as for NinJo, the Nowcasting SAF, and some of the sophisticated nowcasting solutions at MeteoSwiss.



Real-time prediction of cloud movement showing a split of atmospheric streams north of Greece (Photo: EUMETSAT)



Real-time nowcasting increases airspace safety (Photo: EUMETSAT)

Robustness and operation

Users have found CineSat to be extremely robust. When upgrading systems at customer sites, the company has often encountered instances of CineSat running continuously without any problems for several years. CineSat's automatic production survives full disks, network failures and even power outages.

In an incident at one national weather service, a user reported that its IT department had accidentally switched off a CineSat server after two years of uninterrupted, fault-free operation. When its forecasters complained about missing images and nowcasts, the operator was somewhat at a loss as to the CineSat start-up procedures, as for years there had been no need to do this.

In the first instance, they simply powered-up the server again and, to their great surprise, this did the trick perfectly. CineSat resumed normal real-time production automatically, without any further operator interaction.

Since then, a standard operator instruction has been: Don't pull the plug. ∎

HUNDREDS OF METEO PRODUCTS PER HOUR

A typical application of CineSat at national meteorological centers is the continuous automated real-time production of hundreds of products per hour for internal and external end-users. These are provided for road services, construction business, search and rescue, agriculture and health, tourist areas, power plants, and many others who have expressed an interest in having the best possible planning, savings and decision support.

Brigitte Scheiber, is part of the CineSat support team, responsible for international contracts and sales

by Michael Richardson

DATA ON THE HOOF

Global Data Services delivers weather data to mobile and web users

A framework has been developed in the USA to enable the public to better use mobile and tablet apps to get accurate nowcasts and forecasts

Increasingly, individuals and organizations worldwide are using mobile devices to access weather information. To enable meteorological institutions to distribute proprietary information to authorized users and the general public, US company Baron Services developed the Global Data Services (GDS) framework. The system's purpose is to provide a conduit through which weather data can be shared with stakeholders in a customer-defined format, using any of several display methods.

Accessed through tablets, smartphones and web browsers, GDS data sets can include both current and forecasted weather conditions, in addition to an organization's existing meteorological data inputs. Assets that can be distributed via the Global Data Services platform include sensor observations (such as Doppler weather radar, remote weather stations and buoy reports); numerical weather prediction models including GFS and BAMS; global satellite imagery; lightning data; and tropical information.

Value-added products and pre-packaged data sets may also be integrated into the service as requirements allow. Data can be provided at local, regional, national and worldwide scales.

A customized tablet app provides news and weather content, along with social media integration, into a single destination. The sponsoring organization's name or logo is prominently featured in the top-left of the app

It's all in the detail

To accomplish cross-platform dissemination of weather data, a flexible API (application programming interface) is employed. An API is a programming library that allows components of an interconnected data and software solution to communicate with each other. In the case of GDS, the API is powered by state-of-the-art data servers in multiple locations for reliable, continuous service. This network is highly scalable, ensuring smooth performance and high tolerance for usage spikes.

Implementations can be performed by Baron or the customer. In either case, the use of common file formats such as JSON, TMS, XML and others allows the GDS to be integrated quickly and seamlessly into web-based services, while a RESTful architecture is used for timely development and implementation.

GDS data is supplied in either text or graphical format, depending on the data product. Graphical products typically involve imagery such as radar measurements or satellite scans, and are used to efficiently transmit data without excessive bandwidth demands. In the case of some data, observations are reported in a textual format. For these products, a compatible app prepares and displays information in a visual, readable format. Other data, such as remote sensor and buoy reports, are a hybrid of both. WMS support is also available for enhanced graphical presentation.

Once collected, quality controlled and prepared, the API data is distributed to any of several implementations.

Mobile and tablet apps

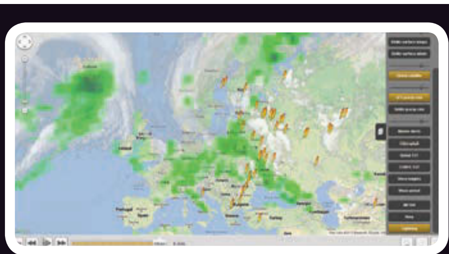
Mobile and tablet applications, or apps, are perhaps the most ideal visualization tool for GDS data, enabling officials in the field or anyone with a compatible mobile device to receive weather information.

Before deployment, apps are customized to the user's requirements, and may carry the logo of the sponsoring entity. They may be distributed over mobile marketplaces such as the iTunes Store and Google Play, where end users may download them for free.

All GDS-enabled apps are customized for mobile operating systems, screen sizes and orientations, and support social sharing of weather content through channels such as Facebook and Twitter. Information from the

WEB WIDGETS

Another type of application powered by the Global Data Services API is a highly customizable web widget, which enables end users to view and interact with weather data as they would through a software program. Controls enabling view manipulation, data product selection and weather tracking can be implemented. Depending on the project requirements, the app's graphical interface can be either designed by the customer, or developed and implemented by Baron.



The Baron GDS enables automated distribution of user-selected weather data to smartphones, tablets and web browsers

app can also be emailed by the user to any acquaintance with an email address. Additionally, the apps provide usage reports, meaning organizations can view detailed metrics on app use. The information provided enables continuous refinements to data presentation.

Notably, GDS weather data can be combined with automated weather alerting, allowing end users to receive notifications specific to up to four monitored locations. GPS functionality enables users to receive warnings for their current location.

Automated weather map export

For implementations involving auto-populated weather imagery on the web, the GDS is used to export pre-selected views and data products to an authorized or publicly accessible website, with no intervention from personnel. Image update intervals are user-defined to occur as often as needed, with images typically exported to the website in either JPEG or PNG formats for ideal balance between picture quality and file size.

A standalone server generates and publishes this content to the web. The system is equipped with continuous auto-updating capability, ensuring all information published is the most timely and accurate available. Image dimensions for export are completely customizable, and can be exported in multiple resolutions. For example, a thumbnail gallery could be generated for the primary landing page, with larger image sizes available in the event a thumbnail is clicked. Real-time webcam and IP cam video can be integrated with the rest of the weather presentation.

The role of the mobile web

Regardless of implementation type, the Global Data Services framework leverages modern communications technologies to effectively distribute timely, relevant weather content. With the ultimate goal of decreasing loss of life due to flooding, winter weather and tornadoes, multiscreen data delivery has a large role to play as organizations look to new ways of improving the public's situational awareness during the outbreak of these life-threatening events. ∎

Michael Richardson is marketing communications manager with Baron Services, based in Huntsville, Alabama, USA

"GDS weather data can be combined with automated weather alerting"

This mobile app provides instant, easy access to weather forecasts, current conditions and radar imagery by Applied Weather Technology

THERE FOR THE JOURNEY

Pertinent questions are asked about voyage routes and passage

The implementation of shipping fleet legislation and fuel prices has had a major effect, but weather prediction data can help route planning

How is your fleet performing compared with the budget? How is a shipping fleet performing under the new IMO energy efficiency regulations, Energy Efficiency Operational Indicator (EEOI), and the Ship Energy Efficiency Management Plan (SEEMP)?

These are by no means easy figures to measure as budgets may need to take seasonality into account. Bunker fuel prices continue to show a tremendous amount of volatility as economic uncertainties continue to drive the market. The calculations may also vary depending on the requirements of separate departments within the shipping company.

Voyage expectation

Weather data compiled over many years means that knowledgeable calculations of voyage expectation can now be carried out. While the output from these calculations may be a simple table and graph, significant science goes into the underlying calculations of wind, seas, swell and ocean currents, plus the performance curves for the vessel itself.

These environmental factors go into the calculation of weather factors and ocean current factors, the response of the ship, and the fuel calculation estimates at various speeds. In spite of the complexity of these calculations, the tools are simple to view and easy to use. The graph on page 146 shows the performance of individual ships, indicated by red dots as compared with the pro-forma data established for the voyage by the operator.

A pro-forma schedule for the route will take many of the variables into account, and these figures, coupled with the predicted weather data and ship-handling characteristics, can determine the expected speed loss for the voyage and the budgeted fuel. The actual results must still be measured against the pro-forma data.
The client is able to set an ideal speed and consumption pro-forma target, and measure ships against that target. The resulting output gives the ship operator the ability to measure individual ship results against the pro-forma expectation.

Legislation implementation

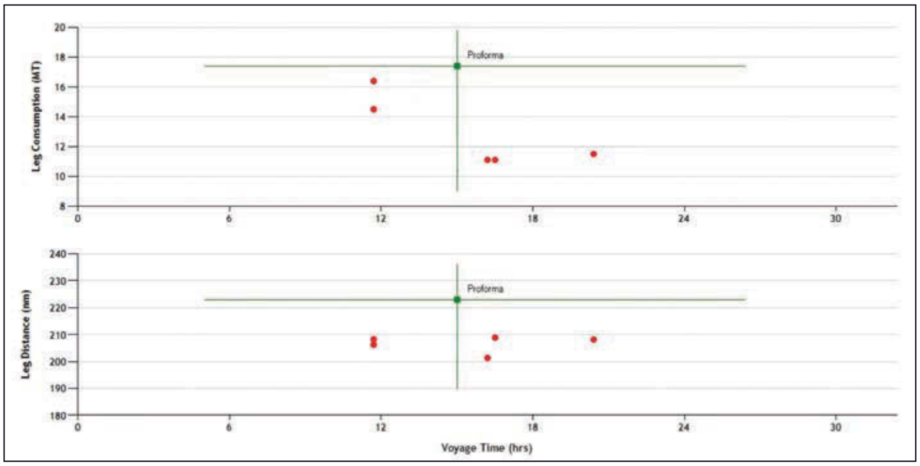
The need for such data became more apparent as a result of the implementation in January 2013 of the IMO's EEOI and SEEMP legislation, requiring ship owners and operators to take steps to improve the efficiency of the ships. New tools were therefore developed to assist clients in making these calculations. The new systems enable clients to monitor total voyage costs from before the voyage begins until the

"The resulting output gives the ship operator the ability to measure individual ship results"

Fuel optimization service process

	Shore-side Operator	Ship Captain
Pre-voyage	• Pre-voyage plan along most efficient route and alternate routes • 4-day graphical forecast • Overall en route time to make ETA • Fuel consumption and total voyage cost	• Recommend most efficient route in terms of least cost, fuel consumption and safety, at speed selected by the client
En route	• Daily Fleet Status reports • Real-time en route calculations of past and future voyage costs via PORTAL • Voyage Alerts	• Continuous en route messages • Detailed voyage and fuel consumption details • Access to AWT's 24-hour Masters hotline
Post voyage	• End of voyage report • Voyage cost analysis	

voyage is completed, making choices along the way to increase voyage efficiency.



Performance summary graph with individual vessels. In this case all perform at a speed and consumption below the pro forma expectation

Pre-voyage

The client first produces a route request specifying the vessel's full charter-party speed and consumption, together with any alternate eco-speeds and consumptions being considered. This information is then used to determine the safest and most efficient route, including the recommended speed if a required ETA is provided.

Information is then assembled in a pre-voyage report, which is sent to the ship's operator. This includes detailed information on the recommended route and up to four additional alternative route scenarios, including a four-day forecast of conditions and calculations of the overall time, consumption and costs for the voyage.

The ship owner/operator is then able to use this data to decide the calm sea speed setting for the passage and select the best of the available options to meet their requirements for the voyage.

The ship's master is then advised of the route recommendation and sets the engine power setting to obtain the required calm sea speed. This power setting is unchanged through the voyage and the ship's speed will vary with the prevailing sea conditions. This variation in speed is accounted for in the routing calculations from the ship's performance characteristics. The constant power setting ensures that the ship does not try to maintain a set speed if the weather deteriorates, thus ensuring the greatest fuel economy.

En route

During the voyage, the route and vessel performance are closely monitored in relation to speed and consumption, providing the shipowner/operator with daily information on the status of vessel via a secure web portal. The ship provides daily reports of position, course, speed, observed weather, and fuel consumption figures. Other methods, such as polling or global AIS may be also employed as required.

Post voyage

On completion of the voyage, the client is provided with an end-of-voyage report. This compares the time en route, consumption and costs along the actual route, with both the instructed speed and full charter-party speed (or recommended speed to make an ETA if requested). This enables the operator to quantify and report on savings achieved. ∎

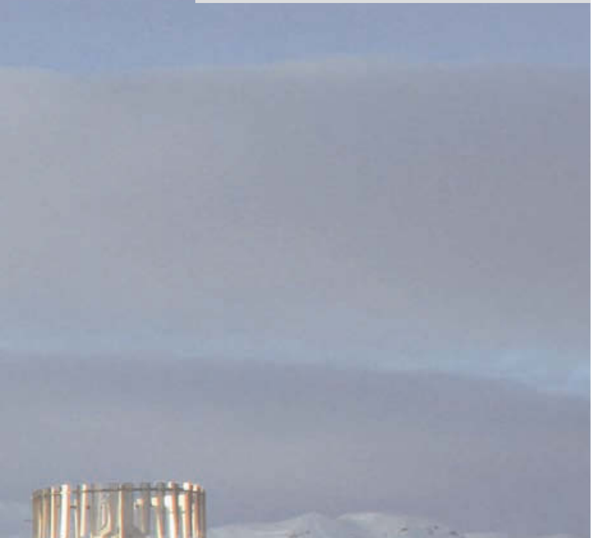
Applied Weather Technology (Europe) is in Aberdeen, UK

by Rodica Nitu

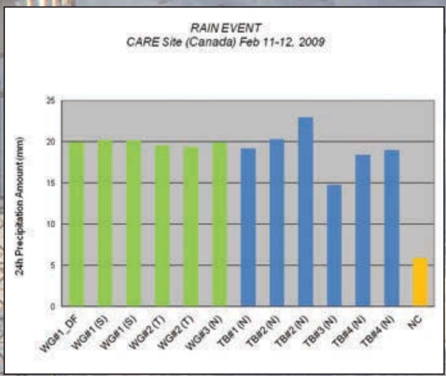
COLD AS SPICE

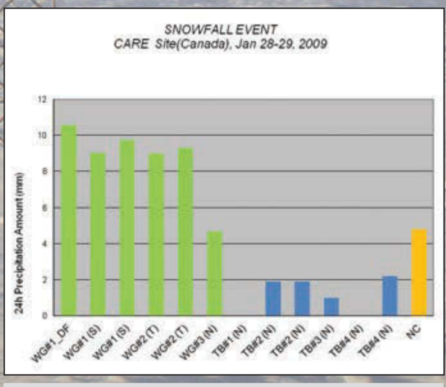
Determining the best way to measure snowfall

A global experiment, known as WMO SPICE, commenced in late 2012 as a joint effort between the WMO members and instrument manufacturers and providers to improve observations of snow



Bratt's Lake (Canada), testing instruments in high winds and very low temperature. (Photo: Craig Smith, Environment Canada)





The accumulated precipitation amount over 24 hours reported from different automatic gauges and configurations are influenced by the precipitation type. Results from the Canadian Centre for Atmospheric Research Experiments (CARE). (WG – weighing gauges; TB – tipping bucket type gauges, DF (DFIR) double-fence intercomparison reference shield, S for single-Alter shield, T for Tretyakov shield, U for unshielded, and NC for a non-catchment type sensor (optical forward scatter))

It is often said that no two snowflakes are alike. Snowflakes are very complex in size, shape and density. More often than not they stick together or aggregate. In fact, contrary to common belief, very few snow particles are pristine crystals. Perfectly symmetric six sided dendrites or columns occur less than about 10% of the time. It is very difficult to even describe a snowflake. We resort to using the terms equivalent mass or size or shape, or fall speed depending on what we are interested in, when it is all much more complex than that.

No two snow storms are the same, either. They are continental, or maritime or Arctic in nature. Different snowflakes grow in these different conditions, and different snow storms in different locations produce different intensities and proportionally different kinds of snow. Some produce heavy wet snow with large flakes, some light fluffy snow with pristine crystals and some snow forms even in the absence of clouds.

The complex shape of snow crystals is complemented by their light weight. This makes them vulnerable to wind and the turbulent flows around the measurement device, and the accurate measurement of falling snow very difficult. By measurement we mean water equivalent and accumulated snow on the ground, over various intervals, from minutes to seasons, and from one location to another. Many systems (catchment type) try to catch the falling snowflakes, while others try to avoid the stagnation area problem by imaging, light scattering or microwave backscattering (non-catchment type).

Of all factors influencing the ability to accurately measure falling snow, wind is the most important source of errors. An increase in wind speed leads to a greater underestimate of snowfall, because snow is diverted from falling into the measuring device or through the measuring volume. At the same time, wind can cause an overestimate of snowfall, as blowing snow can be identified by measuring instruments as falling snow.

Accurate temporal measurements or estimates of precipitation, snowfall included, are required by in-situ sensors, for short-term forecasting and nowcasting, which are critical to everyday life. Snowfall and snow cover are important as the water content of snowpack relates directly to the amount of water ending up in rivers, streams, reservoirs and irrigation canals, while climate models rely on observations of snowfall and snowpack when projecting future water-cycle trends.

Additionally, radar and satellite derived estimates of solid precipitation need corresponding high temporal in-situ measurements, which emphasizes the need for reliable automated measurements of solid precipitation.

Achieving the needed accuracy of measurement of snowfall has been a challenge for users of the data as well as the developers of instruments. While advances in technology could provide improvements, the increasing variety of automatic instruments and configurations used for measuring snowfall has consequences for the accuracy and homogeneity of local and global precipitation time series, with impact on applications such as climate change, nowcasting, water supply, complex terrain forecasting and avalanche warnings (bar figure, left).

Instrument developers and users have understood very well that this information can only be answered at the international level, through a coordinated engagement of expertise and technologies available. No one group can do it all. As a result, the World Meteorological Organization (WMO) initiated the organization of a multisite intercomparison of instruments and methods of observation of solid precipitation – snowfall – and snow on the ground. The project, known as WMO SPICE, commenced in late 2012 as a joint effort of WMO members and instrument manufacturers and providers, and will run for two winter seasons.

SPICE objectives

Globally the transition from manual to automatic instruments has accelerated substantially in the past two decades. An increasingly large variety of automatic instruments and configurations is being used worldwide for measuring snowfall and snow on the ground and this is even true within the same country. At the same time, new non-catchment techniques are being used to derive precipitation amounts, intensity and type.

Based on consultations with a large number of stakeholders, national meteorological services, the WMO Commissions, the World Climate Research Program, the WMO Executive Council for Polar Observations, Research, and Services (EC-PORS), the Global Climate Observing System (GCOS) and the remote sensing community, SPICE will focus on meeting some of the most important needs regarding the quality and availability of reliable solid precipitation data.

During the project, the participants will test current and emerging instruments and will develop success metrics for automated sensors that observe and measure solid precipitation, snowfall and snow depth at a point, at different temporal scales

Legend

1.	Caribou Creek, Saskatchewan, Canada	11.	Haukeliseter, Norway
2.	Bratt's Lake, Saskatchewan, Canada	12.	FMI/Sodankylä Arctic Research Centre, Finland
3.	Marshall Site, Colorado, USA	13.	Valdai, State Hydrological Institute, Russia
4.	CARE, Ontario, Canada	14.	Voljskaya Observatory, Gorodec, Russia
5.	Tapado AWS, Región de Coquimbo, Chile	15.	Pyramid Observatory, Nepal
6.	Formigal, Spain	16.	Gochang, Korea
7.	Col de Porte, France	17.	Joetsu, Japan
8.	Weissfluhjoch, Davos, Switzerland	18.	Rikubetu, Hokkaido, Japan
9.	Forni Glacier, Italy	19.	Guthega Dam, New South Wales, Australia
10.	Hala Gasienicowa Station, Poland	20.	Mueller Hut Weather Station, New Zealand

WMO SPICE sites 2013

and in diverse meteorological conditions. Recommendations will be made on the accuracy of measurement of solid precipitation, on improvements to instruments, and on their use in operational applications including in remote and extreme conditions (operating on batteries, arctic environments and high altitudes).

SPICE's recommendation will be for well-characterized automated field-reference systems for the unattended measurement of solid precipitation, with high temporal resolution. Currently the only well-characterized field reference for the measurement of solid precipitation worldwide is the Double Fence International Reference (DFIR), recommended at the end of the previous intercomparison for the measurement of solid precipitation, organized by WMO between 1987 and 1993. This is a structure of two concentric fences, with the outside diameter at 12m and a height of at least 3.5m, surrounding a manual Tretyakov gauge, the content of which is measured manually, twice a day.

In addition the impact of wind on the ability to accurately measure snowfall is a key focus of SPICE, and adjustment or transfer functions to account for wind induced errors will be developed and made available for all configurations tested.

Organization of WMO SPICE

As the challenge of accurately measuring snow is not limited to any one user or country, participation in SPICE is already impressive. Teams from 15 countries are running SPICE on 20 field sites, on four continents, on both hemispheres, and in climates and conditions representative of cold and alpine environments around the globe.

The same can be said about the technologies tested. The instruments included in the experiment are representative of all measuring principles currently applied for the measurement of solid precipitation (catchment and non-catchment) and snow on the ground. In addition to the host organizations, 22 instrument providers, mostly commercial entities, have provided a total of 28 types of instrument.

The Hydrometeorological Equipment Industry Association (HMEI) was actively involved during the planning phase of the project and made important contributions. The SPICE Organizing Committee encourages active cooperation between the host organizations and the instrument providers.

Each of the 20 sites brings unique conditions and challenges, which provide the premises for a thorough evaluation of the instruments and for the derivation of representative results. The global distribution of the sites is complemented by a good representation of altitudes, varying from sea level (Gochang Observatory, Republic of Korea, and the two sites in Japan – Joetsu and Rikubetu) up to 5,050m (the Pyramid International Laboratory Observatory in Nepal, a contribution of Italy's Everest-K2-CNR Committee. Current and emerging catchment and non-catchment technologies used worldwide for the measurement of precipitation are tested in SPICE, in multiple configurations on various sites.

The tipping buckets and weighing gauges are the traditional catchment type instruments. The tipping buckets provide a large percentage of the measurements of precipitation in all climates, and in a heated configuration are used extensively in cold climates. The weighing gauges included in SPICE represent all the measuring principles and capacities currently used operationally. Heating of tipping buckets and weighing gauges addresses ice build-up and snow capping, and is a focus of SPICE.

Non-catchment type sensors are of particular interest in SPICE, as only recently have they been used for estimating snowfall. To determine the type of precipitation and estimate its intensity and accumulation, they use various physical principles including scattering or obscuration of light by hydrometeors, heat transfer, microwave backscatter and imaging.

SPICE will also assess the instruments measuring snow depth and snow water equivalent. Ultrasonic and laser-based depth sensors, as well as newer technologies using GPS signals for the derivation of the snow depth, will be investigated.

SPICE results

The results of SPICE will be reported in a WMO Final Report, expected in 2016. The project teams have been working closely with the instrument providers to ensure the proper configuration of the experiments.

Given the duration of the experiment, the broad engagements and the need to validate the experiment results, partial results will be published as they become available. They are expected to enable active and productive conversations among scientists and instrument experts, leading to concrete answers to the key SPICE questions on how best to measure snow. ∎

Rodica Nitu is an engineer managing the Observing Systems and Engineering group of Environment Canada and is also SPICE Chair of the International Organizing Committee and Project Lead for the WMO. *Nitu wishes to thank all SPICE team members for their efforts in running SPICE. Special thanks to Dr Paul Joe, Environment Canada, for his support in preparing this article*

by James Anderson

FAST FACTS

Powering real-time weather forecasts and alerts with greater accuracy and speed

ENcast solves the biggest numerical weather prediction challenges and provides highly accurate hourly weather forecasts from 0-15 days

The increasing frequency and severity of weather events due to changing land-use patterns as the global population grows in urban and coastal areas, necessitate more accurate weather forecasts and increased vigilance in monitoring severe weather events. Enterprise organizations and government agencies – such as airlines, utilities, oil and gas companies, public safety and civil aviation operations – all strive for greater efficiency despite increasing demands. To save lives and protect assets, these entities require as much advance lead time to severe weather as possible.

Real-time surface weather observations, and in-cloud, cloud-to-ground, or total lightning detection data, can be used to initialize forecast models and identify severe weather threats, which in turn deliver major improvements in forecast accuracy and warning lead times. Through research and product development, Earth Networks and its partners are improving weather forecasts, advancing the identification and tracking of severe weather, and providing timely alerts to enterprises and government agencies so they can know before disasters strike.

ENcast

A timely and accurate forecast is essential to enterprise and government operations. It's a core piece of information that nearly everyone checks before leaving home. An accurate forecast is also very hard to make. Numerous challenges exist in weather forecasting; the major ones are summarized in Figure 1. Many of these limitations build on each other.

Earth Networks and its partners developed a variety of forecasting techniques to overcome many of these challenges and provide the best forecast possible. Using a cloud computing environment, ensemble models are run in high frequency with input of highly granular surface weather observation and total lightning data. This approach helps substantially improve forecast accuracy, on an average by 25% (predicted versus actual root mean square error or RMSE; Figure 2).

“ENTLS total lightning data is combined with sophisticated algorithms to generate DTAs”

Infusing localized, real-time weather data into ensemble weather prediction improves accuracy, especially in the short term, as does using the highest-resolution models, eliminating model bias, and updating the forecast as much as every hour with the latest observations.

ENcast uses a linear-regression based statistical methodology that includes initial conditions input from Earth Networks’ surface weather observation and total lightning detection networks. These create the model output statistics (MOS) for each model in the ensemble. Total lightning data, which includes in-cloud lightning, is an essential input to ENcast. Using only cloud-to-ground data does not produce the same results. The MOS corrections are constantly changing to include the most accurate statistical representation of the biases of each model. The optimal combination of corrected forecasts is then used to create the ensemble forecast. Finally, local observations further nudge the model for the specific forecast location.

Combining real-time, neighborhood-level weather and lightning observations, the best-performing set of global models – including the ECMWF, the highest-resolution global model – and hourly updates creates ensemble models that surpass the accuracy of individual models and other common forecast outputs.

ENcast delivers additional benefits, including:
• Lowest forecast error for 0-15 days using a set of best-performing global forecast models;
• Hyper-local nowcast advantage derived by tuning forecasts with Earth Networks’ temporal and spatial observations;
• Faster forecast updates harnessing cloud computing to deliver hourly forecast updates out to six days;
• Global coverage through Earth Networks, METAR and custom sensor locations;
• Turnkey sensor and software solution from a single provider for hourly forecasts delivered from the sensor direct to the application;
• The most complete forecast coverage from city to location to sensor – any point, anywhere on the globe. The ENcast forecast is generated for more than 2.6 million cities worldwide. Tuning the forecast with real-time weather and lightning observations enables pinpoint accuracy in the 0-18 hour range. In fact, nowcast forecasts have been shown to be on average 25% more accurate than other model predictions (see Figure 3).

This forecast improvement continues to five days and beyond. Figure 4 shows the RMSE analysis per model for 0-15 hours. ENcast consistently delivers the lowest RMSE of top global forecast models.

ENcast is provided in three forecast products. The main forecast features are summarized in Figure 5 (overleaf). The consumer forecast is the City Forecast. The Location Forecast is a gridded forecast for any location in the world. The Sensor Forecast is available where suitable surface weather data exists to correct the forecast for local conditions.

All the technical and process improvements in ENcast generate a highly accurate forecast. The graphs in Figures 6 and 7 show the ENcast forecast performance relative to other common forecasts.

PulseRad

Another very commonly used tool for severe weather monitoring is radar. Unfortunately it can be very expensive, as well as costly and technically complex to operate. Infrastructure, availability of trained professionals for support and maintenance, and limits on radar efficacy in mountainous areas may make it impractical for various applications.

PulseRad is a lightning-based proxy radar solution that overcomes many of these challenges. Earth Networks developed a global lightning detection network known as the Earth Networks Total Lightning System (ENTLS). Data from the ENTLS enable the creation of practical and cost-effective proxy radar that can provide an interactive map of convective weather. Distinct algorithms for different climate zones (mountainous, tropical and subtropical) within a forecast area are seamlessly integrated into a proxy radar map to ensure accuracy and reliability. PulseRad is used for precipitation estimation

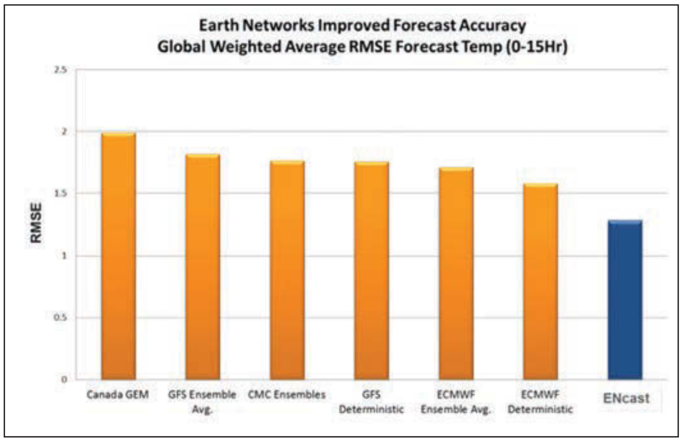


Figure 3: Temperature forecast accuracy for 0-15 hours. Demonstrating the benefit of utilizing local observations

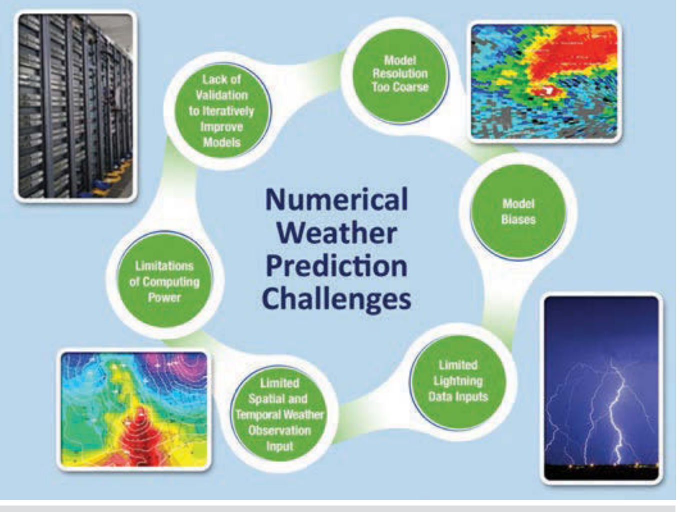


Figure 1: Numerical weather prediction challenges

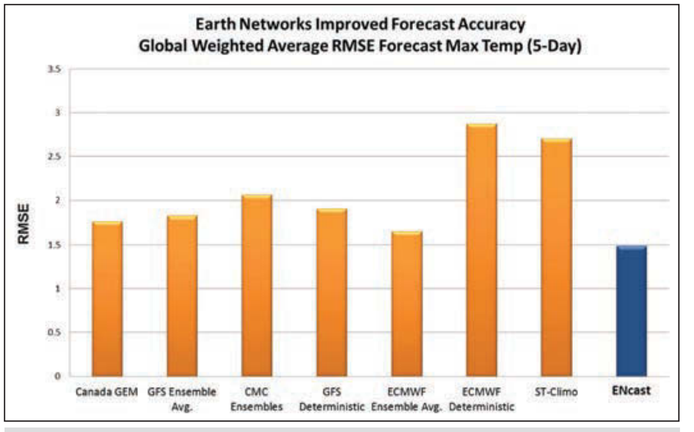


Figure 4: ENcast delivers lowest RMSE compared with other global models

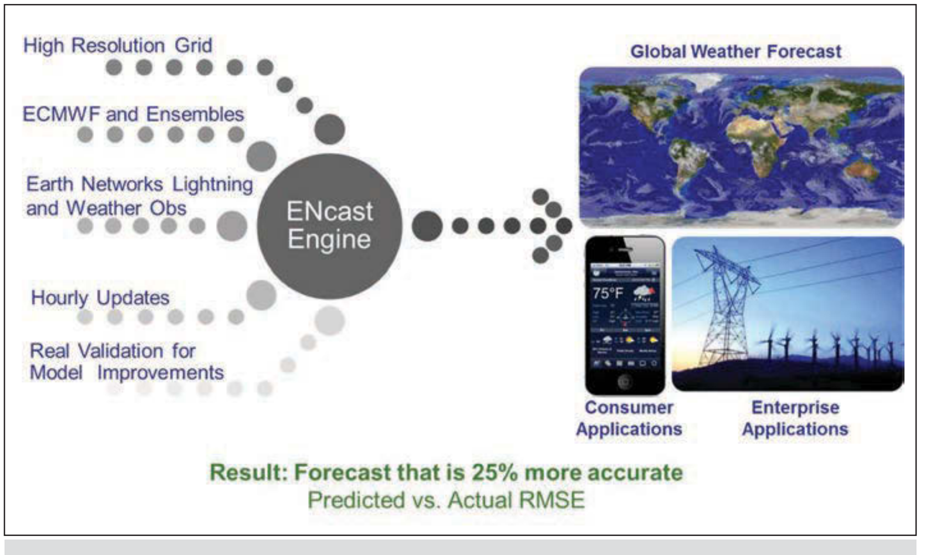
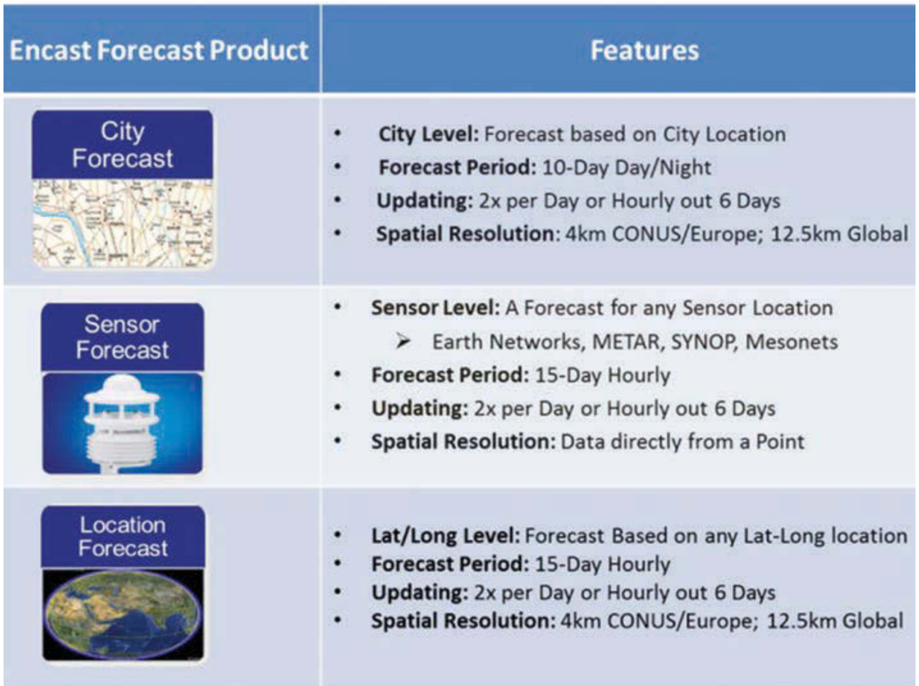


Figure 2: Forecast inputs for ENcast

when tracked over time (days, weeks, months, quarters or years) to produce rainfall accumulation maps. This provides forecasters with insight into potential drought or flooding conditions within the forecast region. Key benefits of PulseRad include: identification and advanced warning of dangerous storms; flood prediction and drought assessment on a national scale; extended coverage in mountainous and oceanic regions; and real-time information at a fraction of the cost of radar.

Dangerous thunderstorm alerts

Dangerous thunderstorm alerts (DTAs) further refine the capability of PulseRad. The DTA system specifically tracks the patterns in in-cloud and cloud-to-ground ratios, the rate of change in lightning activity, and the density of lightning flashes to identify severe storm cells and determine when they have reached a severe level.



Encast Forecast Product	Features
City Forecast	• **City Level:** Forecast based on City Location • **Forecast Period:** 10-Day Day/Night • **Updating:** 2x per Day or Hourly out 6 Days • **Spatial Resolution:** 4km CONUS/Europe; 12.5km Global
Sensor Forecast	• **Sensor Level:** A Forecast for any Sensor Location ➢ Earth Networks, METAR, SYNOP, Mesonets • **Forecast Period:** 15-Day Hourly • **Updating:** 2x per Day or Hourly out 6 Days • **Spatial Resolution:** Data directly from a Point
Location Forecast	• **Lat/Long Level:** Forecast Based on any Lat-Long location • **Forecast Period:** 15-Day Hourly • **Updating:** 2x per Day or Hourly out 6 Days • **Spatial Resolution:** 4km CONUS/Europe; 12.5km Global

Figure 5: ENcast forecast options

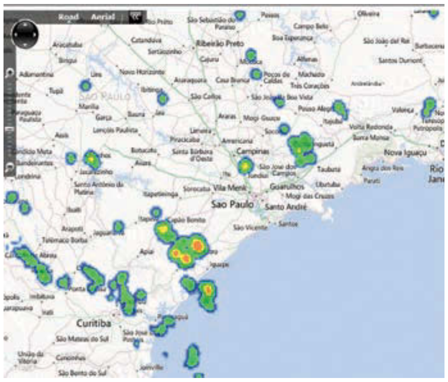


Figure 8: PulseRad in Brazil

ENTLS total lightning data is combined with sophisticated algorithms to generate DTAs, which provide an average of 45 minutes' lead time for severe weather. The alert is visually depicted by a purple polygon encompassing the alert area and displays the area, size, direction and speed of the severe lightning activity. The alert is updated every 15 minutes until the dangerous weather activity is no longer a threat and the alert expires. DTAs are issued when there is a high frequency of lightning, indicating the increased potential for cloud-to-ground lightning strikes, heavy rain rates, high winds, downburst winds, and hail and tornadoes.

Extensive analysis has shown that DTAs offer more advanced warning – 50% more lead time on average – than many other types of alerts.

Customized, real-time proximity alerting

The Earth Networks Early Warning System makes it possible to display and send severe storm warnings and proximity alerts to email, mobile and audio-visual alerting devices. This system is also designed for centralized control room operations through an easy-to-use web display. Whether on the desktop or in the field of operations, this delivery flexibility provides real-time insight into weather conditions, analysis and automated alerting. Customized proximity alerts for areas surrounding key assets can be set by address or the latitude/longitude coordinates of the operational facility. Earth Networks also makes it possible to track real-time and historical lightning information around assets based on custom alert regions.

Earth Networks and its partners continue to conduct research and refine advanced solutions that deliver major improvements in forecast accuracy and warning lead times. Through the ongoing development of technologies and expansion of its networks, Earth Networks is empowering enterprise organizations and government agencies with technology to know before when responding to severe weather threats and impacts. ∎

James Anderson is vice president of global network and business development for Earth Networks, the operator of the largest weather monitoring and lightning detection networks and a major provider of global weather data services and solutions. For more information, go to www.EarthNetworks.com

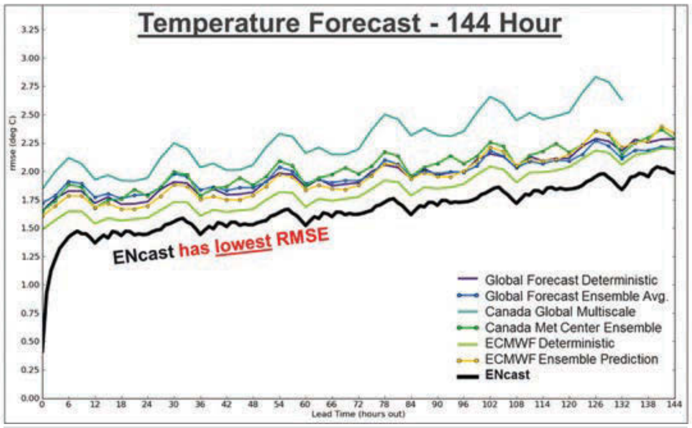


Figure 6: Temperature forecast accuracy

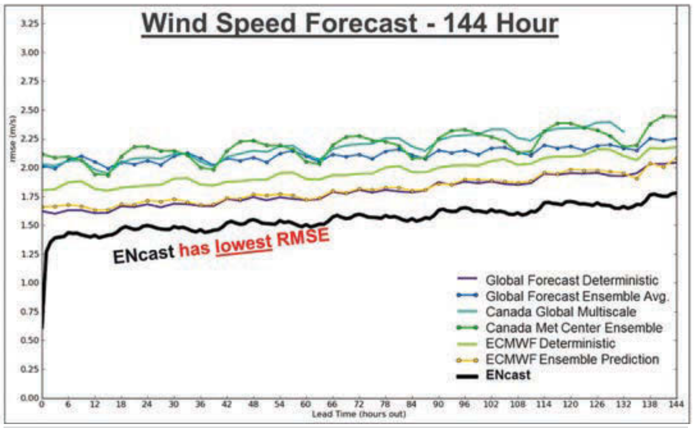


Figure 7: Wind speed forecast accuracy

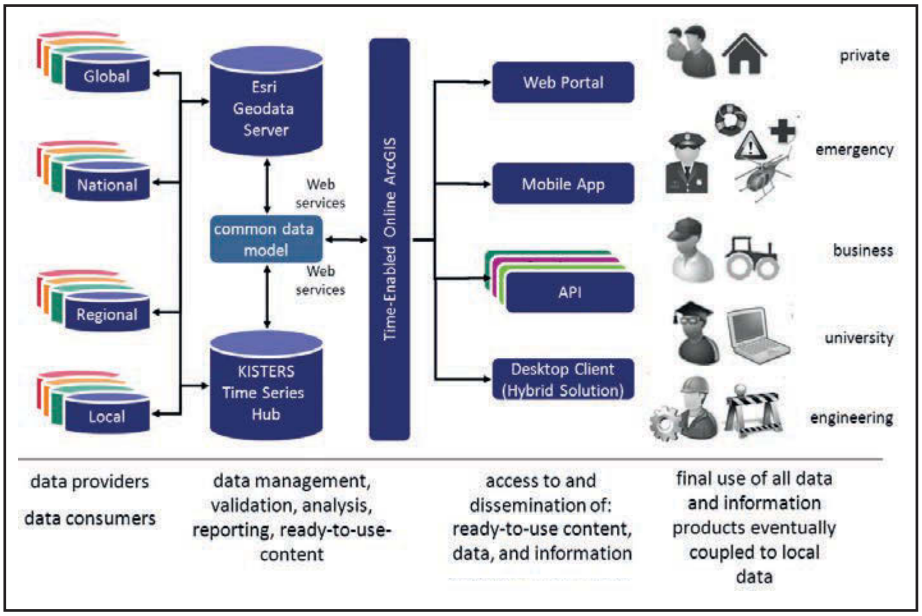
by Edgar Wetzel and Michael Natschke

HOLISTIC VIEW

The next (r)evolution of time series management: time-enabled GIS

Recent advances in IT, interoperability and internet technology have paved the way toward merging temporal and geospatial data into time-enabled GIS

The total amount of measured and observed data in seemingly disparate disciplines is continuously growing. For instance, vast amounts of meteorological and hydrological legacy data completed daily by new measurements are stored in disparate information systems. Merging this data into its common geospatial environment without losing the inherent dynamics of the time series (past, present and future) would yield much better information from the same base data. Perceiving disparate data as a single large data set increases the information density, as correlations can be found to spot environmental trends, and research quality issues, resources distribution and consumption patterns. These insights help to answer today's pressing and increasingly complex scientific and operational questions. Advanced analysis algorithms and visualization techniques enable users to discover and understand the information conveyed in the data. In this big data concept, software unveils hidden information while shielding the users from the complexity of the data and its processing. Typical fields of application are environmental protection, hydro-meteorological data management, natural-disaster planning and management, and industry activities such as logistics and resource use optimization.



Online time-enabled ArcGIS (Esri and KISTERS)

Coupling time series and geospatial data in the cloud

GIS is a logical integration point for seemingly disparate data related by its geospatial references, but it lacks the ability and calculation engines to uncover the dynamics and trends of long time series. On the other hand, time series data management systems are highly efficient number crunchers with limited capabilities to identify geospatial cross-correlations. A time-enabled online GIS couples these applications, providing seamless access to geospatial and temporal data from within a single graphical user interface (GUI).

In a long-term partnership, Esri Inc. and KISTERS AG jointly develop higher levels of time-enabled GIS. The resulting products are used by the public and private sectors in he industry to generate and disseminate mainly meteorological and hydrological information.

Cloud computing unburdens the user from the complexity of software administration and maintenance. Furthermore, total cost of ownership is minimized due to sharing cloud applications with a larger community. Both the GIS and the time series management software can live in the cloud. This is already the case for the Esri ArcGIS Online and KISTERS TSM Data Hubs. A common information model harmonizes data semantics to accommodate

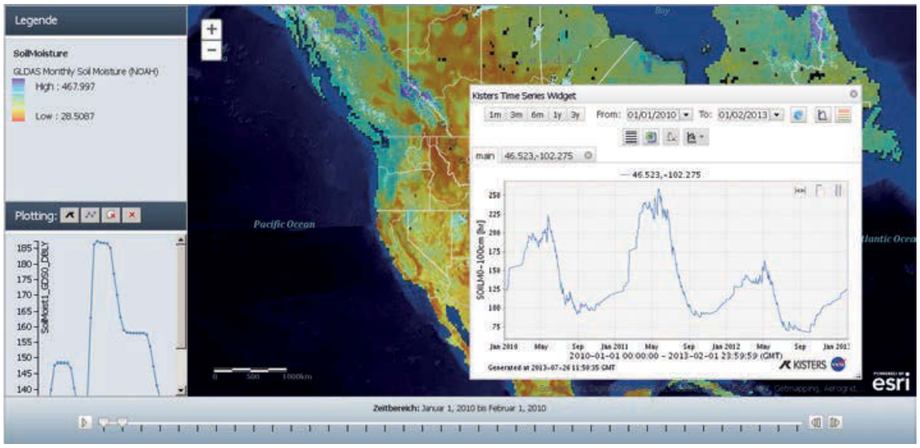


Figure 2 – Time-enabled world soil moisture data – content for World Water Online

"In this big data concept, software unveils hidden information while shielding the users from the complexity of the data and its processing"

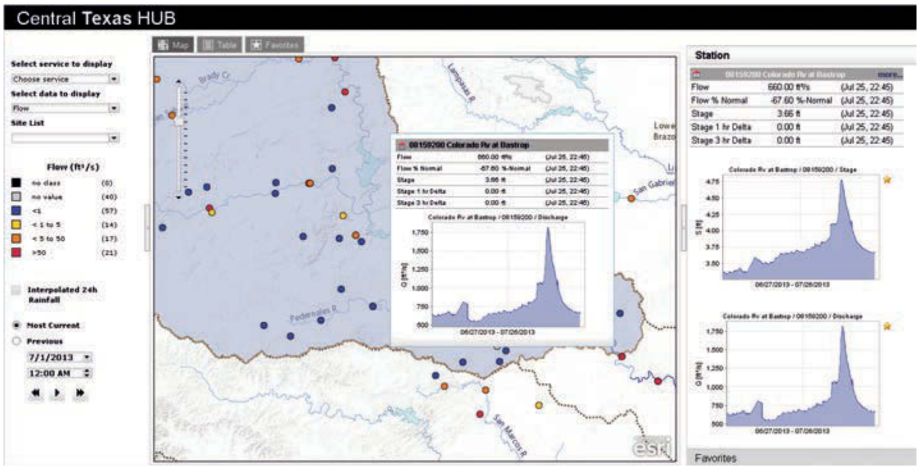
point, raster and vector data. One or several time series data hubs and geo-data servers are hosted somewhere on the internet – or, if data privacy matters, somewhere in the intranet. The web services-based interoperability standard WaterML 2.0, developed by the Open Geospatial Consortium and endorsed by the World Meteorological Organization, bridges the gap between time series data hubs and online GIS. WaterML 2.0 enabled database applications can be queried remotely in a consistent manner. KISTERS Time Series Data Hubs use WaterML 2.0 to find out what data is available in remote databases, select the required data, and import it into their database. Authorized remote applications (internet portals, mobile apps, fat clients) can query the hub and receive data and online derived data products in return. A major goal of this internet service infrastructure is to build the 'system of systems' architecture actively promoted by the Global Earth Observation System of Systems (GEOSS).

The overall concept of the Time-Enabled ArcGIS Online is illustrated in the diagram on page 156. The IT side shows a complex distributed system with Esri Geodata Servers, the KISTERS Time Series Data Hub and numerous databases, whereas the user just sees the ArcGIS Online GUI. The integrated KISTERS web widgets provide data, information and derived data products that are meaningful to the user. Tailor-made applications and services can be added on top by using the internet services application programming interface (API) implemented in scalable software architecture. Ready-to-use content is produced in background processes. Once registered in the database, it remains available to be consumed whenever and wherever a user needs it.

Time-enabled online GIS in practice

The Center for Research in Water Resources (CRWR) of the University of Texas at Austin has joined with Esri of Redlands, California, and KISTERS of Aachen, Germany, to create the foundation system for World Water Online (www.worldwateronline.org), a common data access point to disparate public data sources. In a GEOSS Architecture Implementation Pilot, hydrological and meteorological content will be made available through the site to test the suitability of the internet service infrastructure for GEOSS.

World Water Online API



Central Texas Hub: raising situational awareness

World Water Online is by itself a miniature system of systems. The platform's internet service infrastructure relies on the KISTERS Web Interoperability Solution to serve public data from the KISTERS Time Series Data Hubs through an API.

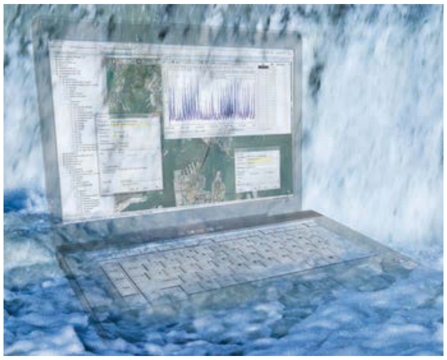
Central Texas Hub

The Central Texas Hub (www.centraltexashub.org) is about raising situational awareness. It integrates water information in space and time across organizations to provide a unified view of flood conditions and storm water for Central Texas.

The public site centralizes available stage, flow and precipitation data from several institutions in a convenient GIS-like environment, featuring KISTERS web widgets to visualize time series. KiWIS queries the various databases and stores the data in a KISTERS Time Series Data Hub. Map, time series and derived data products are available in real time. Both current measurements and legacy data are readily available.

Open GRCA

Grand Rivers Conservation Authority's Open GRCA (http://maps.grandriver.ca/opengrca/) integrates maps, GIS data layers, and meteorological and river monitoring data in an online ArcGIS application publicly accessible through an internet portal. By interconnecting service end points of Esri and KISTERS applications, a whole new information universe is created that was previously unavailable.

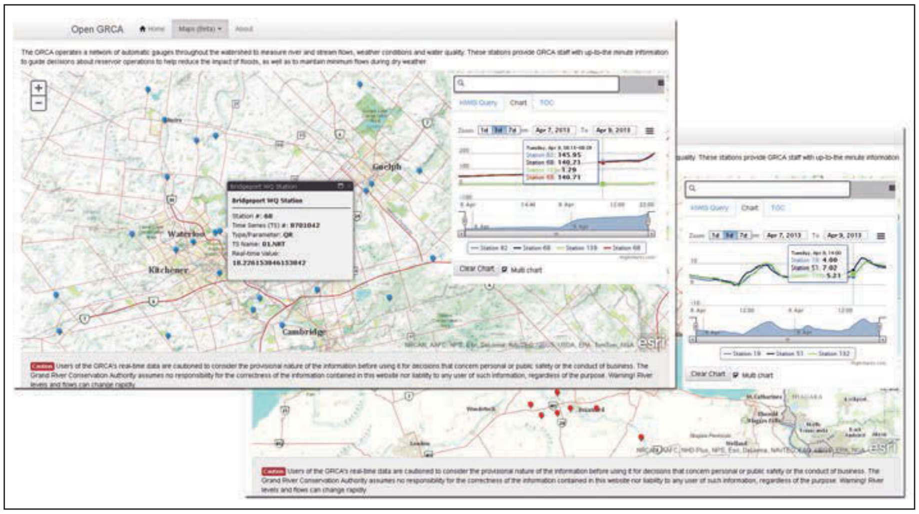


Summary and outlook

Internet services bridge the gap between time series data management and GIS, and make disparate databases interoperable. Time-enabled online GISs are used as the integration point to provide a holistic view of the data: hydrological and meteorological time series are put into their geospatial context, cross-correlated with other time series and transformed into ready-to-use content. Users from the public and the private sectors alike adopt the technology to gain access to better information faster. Decision makers, managers, experts and the general public are served information they need, when they need it, in a format they can use and understand. They focus on information and knowledge building rather than worrying about the complexity of the processes and the IT infrastructure.

The next step for development will be to integrate the current solutions into coordinated, comprehensive and sustained information systems based on the 'system of systems' concept. ∎

Edgar Wetzel is business development manager and Michael Natschke is product manager for water solutions at KISTERS AG



Open GRCA: mapping hydrological and weather time series data through KiWIS

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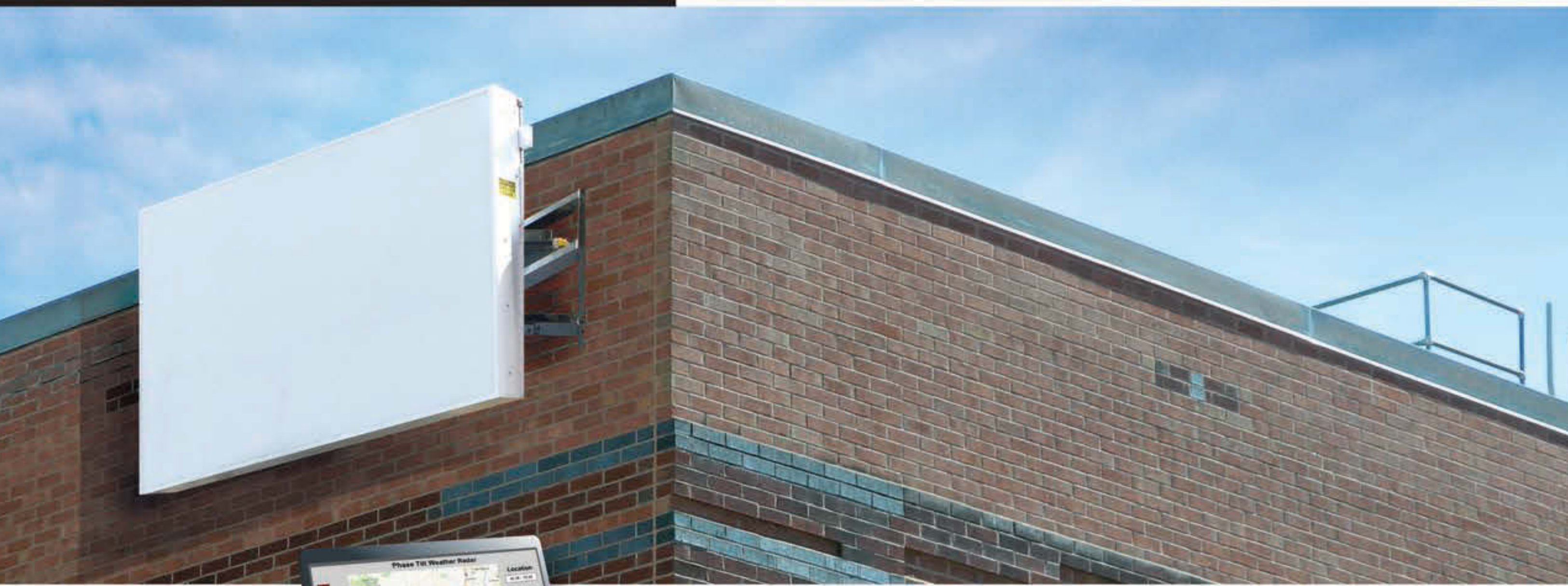

Simple setup and operation, deployable on buildings and towers.

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- Dial Switched Linear Polarization provides standard polarimetric products.
- Interfaces to standard weather display and analysis packages.
- Beta version of a complete radar system is being commercially offered by Raytheon Integrated Defense Systems, Tewkesbury, MA, USA. and FIRST RF Corp., Boulder, CO, USA.
- Customization and research-oriented deployments are also offered by the University of Massachusetts Amherst.

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casa NSF

by Susan Foxall

ACCESS ALL AREAS

Weather monitoring kit specifically designed for use in remote locations

Vantage Connect can track weather data in remote areas – as long as you have mobile coverage

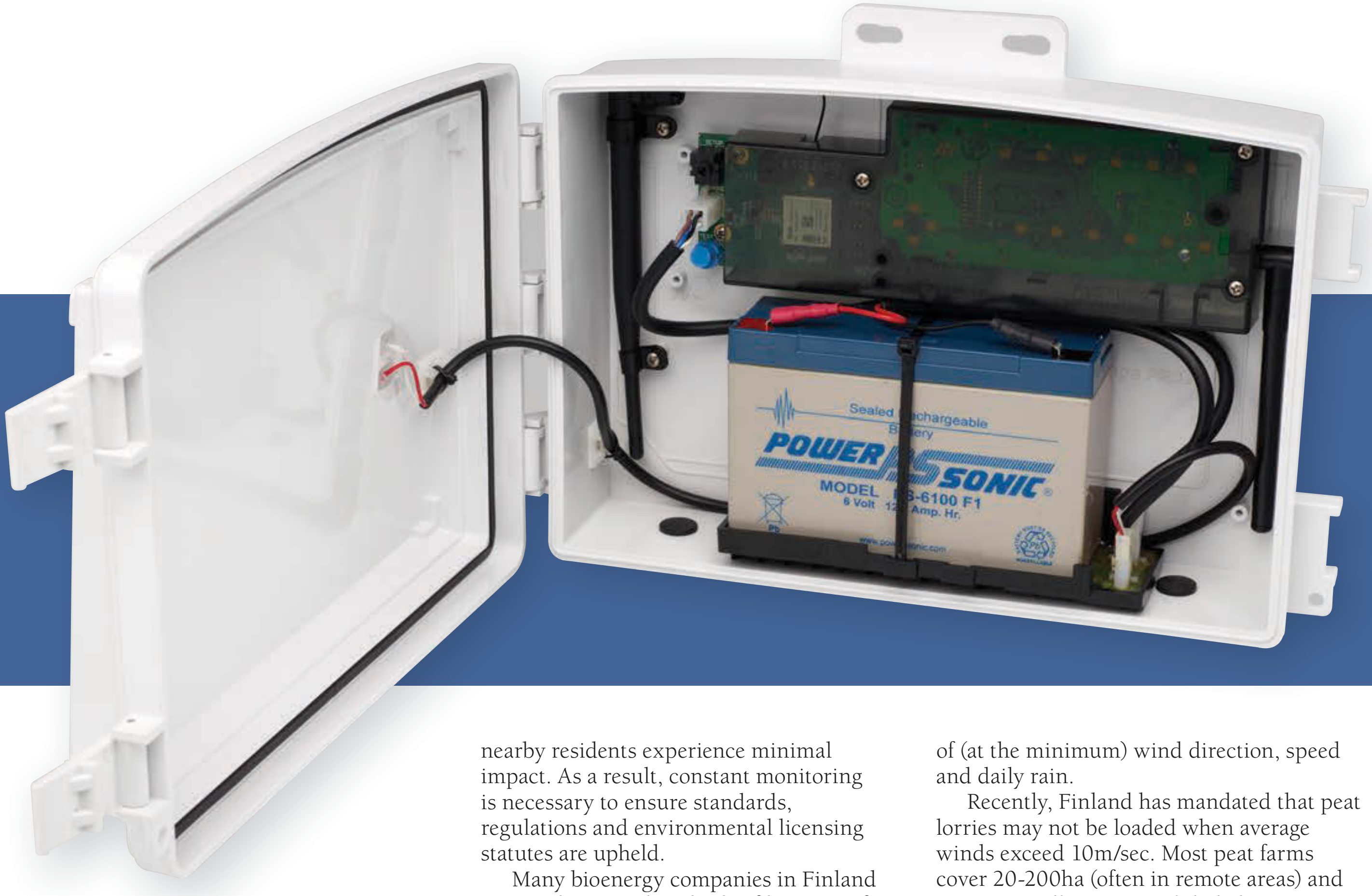
Above and right: Vantage Connect, and the technology inside

It has been said that the only constant about predicting the weather is its unpredictability. Weather shifts in micro-climates are especially difficult to anticipate. Winds may be calm in the immediate area, but could be gusting substantially just a few miles away. This can be particularly difficult to gauge in remote locations where there is no physical entity monitoring the weather. Sometimes livelihoods – and lives – depend on an accurate weather report. Industries such as agriculture, environmental protection, health, fire and public safety need accurate data to make smart decisions.

Vantage Connect, the latest weather monitoring product from US-based Davis Instruments, enables the user to track weather data from any remote location that has mobile coverage. Solar-powered and self-contained, Vantage Connect combines an integrated data logger and mobile modem to report weather data from multiple Davis weather sensor configurations. With this technology, users are provided essential, remote weather information so that they can make educated and informed decisions.

Managing the environment

Several countries have adopted stringent environmental standards and restrictions for specific crops to ensure lands are not over-used, boundaries are maintained, and



"When wind limitations are exceeded, alerts can be sent directly to peat farm managers and/or lorry operators to ensure loading activities cease until the winds are calm"

nearby residents experience minimal impact. As a result, constant monitoring is necessary to ensure standards, regulations and environmental licensing statutes are upheld.

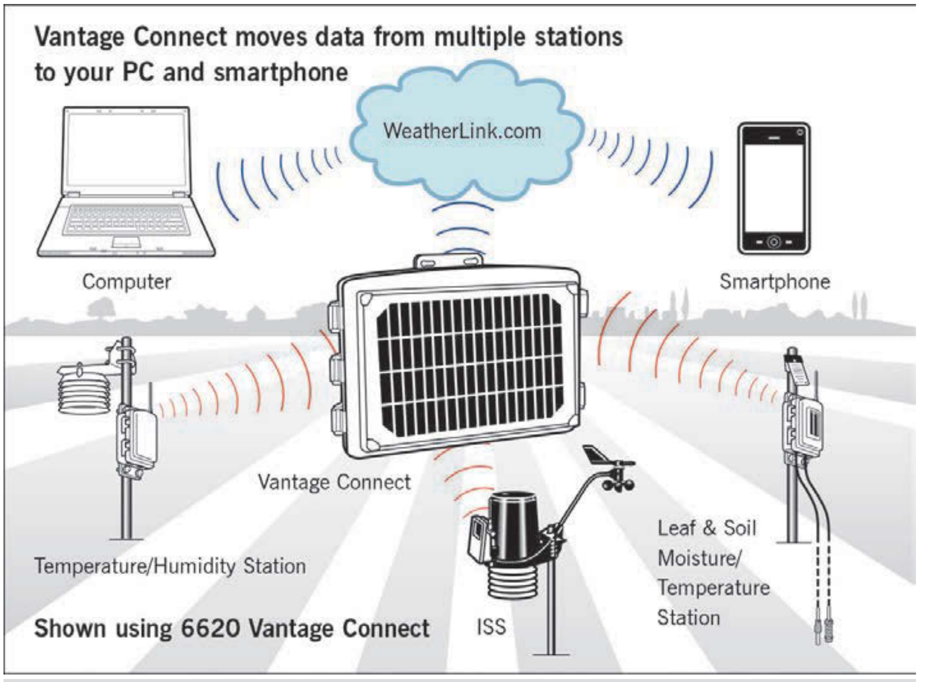
Many bioenergy companies in Finland own and operate hundreds of hectares of peat farms, where crop yields are used to create peat pellets for clean-burning heating fuel. All peat farms are subject to licensing regulations and have implemented various monitoring instrumentation and technology to ensure they remain within compliance. Many companies have chosen to use the Davis Vantage Vue or Vantage Pro2 weather stations along with Vantage Connect to record wind, rain and solar activity. Remote data and real-time weather alarms are essential in managing their environmental footprint as required by production managers and the environmental regulations in Finland.

Each peat farm must have an environmental license and a weather logging system to monitor various weather elements, including wind and rain. During harvest season, peat machinery and related lorries can emit a great deal of dust, noise and odor. Such emissions impact the well-being of the surrounding community and landscape. As part of their environmental licensing proviso, peat production plants must be vigilant in the monitoring and documentation of (at the minimum) wind direction, speed and daily rain.

Recently, Finland has mandated that peat lorries may not be loaded when average winds exceed 10m/sec. Most peat farms cover 20-200ha (often in remote areas) and aren't typically monitored daily by personnel, so changing winds can pose a problem. Data from Vantage Connect and its associated Vantage Pro2 integrated sensor suite is transmitted to a Cloud-based data site where users can monitor all weather variables in real time. When wind limitations are exceeded, alerts can be sent directly to peat farm managers and/or lorry operators to ensure loading activities cease until the winds are calm.

Water run-off is another environmental concern that peat production plants must monitor closely.

According to the International Peat Society, "Drainage is a specific feature of peat usage because over 90% of the weight of natural peat mass is water. Especially at the initial stage of ditching, a lot of water is released and directed by the force of gravitation to streamlets, rivers and lakes, carrying along solid substances and nutrients. Sophisticated mechanical and chemical techniques have been developed to reduce emissions from the drainage network and an acceptable purification level has been achieved under normal working conditions.



How Vantage Connect listens to varying weather stations and transmits data to the cloud

Water legislation varies from country to country, but the new EU Framework Directive in the field of water policy (2000/60/EC) will no doubt, in the long run, lead to harmonization of water quality requirements, including within the peat industry (Sopo, 2004)."

Managing harvesting activities

Finland is home to nearly 200,000 lakes. Excessive run-off from the peat bogs can carry a surplus of various compounds that can upset the lake's natural ecosystem and shorelines. Excessive rain and rapid snow melt can cause bogs to rise rapidly and shed more water than is environmentally acceptable. Peat ditching releases more sediment than would naturally occur, therefore peat production plants must monitor storm activity and rainfall to ensure bog water levels stay within environmentally defined parameters and avoid disproportionate run-off. Using the rain data and real-time alarms from their Vantage Connect units, peat farmers can better manage harvesting activities without compromising the environment or productivity. Vantage Connect is specifically designed for remote locations; it requires no additional power sources and is equipped with a heavy-duty back-up battery that supplies ancillary power in areas with little or no light.

In locations where rapidly changing weather conditions require a timely response – such as Finnish peat bogs, or freezing temperatures at a vineyard or citrus farm – Vantage Connect can be programmed to send vital real-time email and text alarms that can be viewed on a PC, smartphone or tablet – in fact, anywhere there is an internet connection.

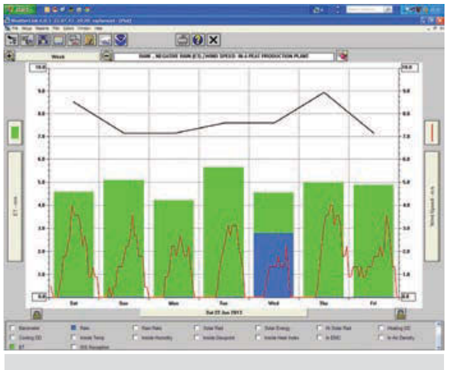
Available in both wireless and cabled versions, Vantage Connect works in concert with the Davis integrated sensor suites and special purpose stations to send weather data directly to the cloud. Wireless Vantage Connect is radio-compatible with Davis transmitters and repeaters for extended range and is easily integrated into an existing Davis weather station.

Vantage Pro2 weather stations are rugged and stand up to the elements – a necessity for any farmer. The integrated sensor suite is comprised of a rain collector, temperature and humidity sensors, and an anemometer. Like Vantage Connect, the Vantage Pro2 weather station is available in a wireless or cabled configuration, providing the user flexibility depending upon the application. In this instance, the peat farms do not have external power sources, so they rely on the solar-powered, wireless versions of both instruments. Vantage Connect communicates with the Vantage Pro2's integrated sensor suite to obtain weather data that is transmitted via mobile technology to the user's secure website on WeatherLink.com.

WeatherLink.com is Davis Instruments' global network of weather stations. Each reporting station has its own page on the site and is shown on a map as a temperature-color-coded dot. Selecting a dot shows easy-to-view weather data.

It is important to note that the largest Finnish peat corporation, Vapo, is openly publishing its recorded data to WeatherLink.com. According to Ilkka A Lilja, of Ilkka Lilja Oy, the Davis Instruments distributor in Finland, "Vapo Corp has modern directors and environmental officers who are excited to openly show their data to the public and environmental officials. Although most pages are kept private, Vapo's environmental management were honored to share the results from their remote data in real time."

Without question, the effect of weather on a multitude of industries will continue to influence – and in some instances reshape – the approach to business activities. Advances in technology have made weather instrumentation more affordable and better able to address businesses' monitoring requirements. Vantage Connect from Davis Instruments is one such example. With its real-time reporting capabilities, data from remote areas can be visualized anywhere there is a mobile connection. Quite literally, Vantage Connect brings far off, micro-climate activity to the palm of your hand. ∎



Vapo data graph reporting wind and rain measurements

Susan Foxall is the director of marketing at Davis Instruments , based in the UK

by Kurt Nemeth

WINNING FORMULA

The water cycle: evapotranspiration and precipitation

The deployment of remote automatic weather stations to determine evapotranspiration according to the Penman-Monteith formula

Efficient water management has become increasingly important as the world struggles to feed growing populations and as climate change places increasing pressure on those regions that already suffer from water shortages and drought. The increased frequency of extreme weather events also contributes to the growing pressure on water resources.

According to the United Nations, water usage has grown at more than twice the rate of population increase over the past century. In 2006, it was calculated that more than 1.4 billion people live in river basins where water use exceeds minimum recharge levels.

Around 70% of freshwater usage is for irrigation, 20% for industry and 10% for domestic use. Globally, irrigated agriculture accounts for around 20% of cultivated land but contributes 40% of total food production (FAO, 2012).

The agricultural and horticultural industries consume enormous quantities of water, so the challenge is to use the correct amount of water to maximize production without waste. To achieve this, it is necessary to determine the volume of water that is required by a specific crop as it grows. This information can then be utilized to manage irrigation.

Evapotranspiration

Evapotranspiration is an important component of the water cycle. It is the sum of evaporation and plant transpiration from the Earth's surface to the atmosphere. Evaporation is the movement of water to the air from sources such as the soil, plant canopies and water bodies. Transpiration is

OTT's automatic weather station consists of a 2m mast to measure wind, temperature, humidity and global radiation, a solar power package, data logger, remote transmission unit and precipitation gauge with windshield

"Evaporation from pans has been decreasing for the past half century in many regions of the world"

the movement of water within a plant and the subsequent loss of water as vapor through the stomata in leaves. The energy that drives these processes comes from solar and terrestrial radiation. The rate is influenced by a complex interaction of many factors, including the topography, geology and botany of the area, the moisture content of the soil, the moisture availability to vegetation, and the local weather. As many of these factors vary throughout each day and with the seasons, the rates are continually changing at any given site. This means it is not possible to measure evapotranspiration directly.

An evaporation pan is a practical way to measure the loss of water from a small water surface. However, this is not a direct measurement of part of the natural evapotranspiration process. Furthermore, evaporation rates from lakes, soil surfaces and vegetation will be different from a pan and therefore have to be determined using empirical methods.

Conventional evaporation station

A conventional station consists of a Class A evaporation pan, a stilling well, a mechanical micrometer to record daily evaporation from a water-filled tank, an anemometer and a floating water temperature sensor. In addition, precipitation is measured by a manual check gauge, which provides daily precipitation data for inclusion in the evaporation model.

Obviously, this human observation at specific times is an offline, time-consuming and costly method.

It has been noted that evaporation from pans has been decreasing for the past half century in many regions of the world. However, the significance of this trend, with regard to terrestrial evaporation, is still somewhat controversial, and its implications for the global hydrologic cycle remain unclear. The controversy stems from the alternative views that these evaporative changes resulted either from global radiative dimming (from airborne particulates), or from the complementary relationship between pan and terrestrial evaporation. These factors are not mutually exclusive but act concurrently.

Example of a Class A evaporation pan with micro-meter, floating thermometer and anemometer with a manual raingauge

Use of the Penman-Monteith formula

It is possible to measure meteorological parameters automatically and to calculate evaporation based on the measured values for wind run, temperature, humidity, global radiation and precipitation.

The Penman-Monteith equation is used to calculate potential evaporation:

$E_0\ [cm\ day^{-1}]$

$$E_0 = \frac{\frac{100Q_n}{\rho L}\Delta + E_a\gamma}{\Delta + \gamma}$$

$Q_n = Q_s - Q_{rs} - Q_{lw}\quad [Jm^{-2}day^{-1}]$

$\Delta = slope\ of\ the\ T_a - e_{sa}\ curve$

$\rho = density\ of\ water\ = 1000\ kg\ m^{-3}$

$\gamma = 0.66 mb°C^{-1}$

$E_a = (0.013 + 0.00016u_2)(e_{sa} - e_a)$

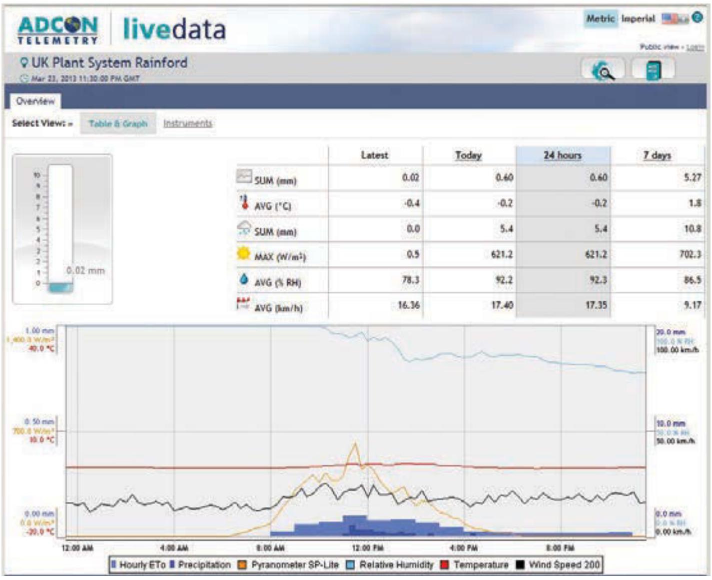
$L = latent\ heat\ of\ vaporisation = 2.47$

$e_{sa} = saturation\ vapor\ pressure\ at\ air\ temperature\ [mb]$

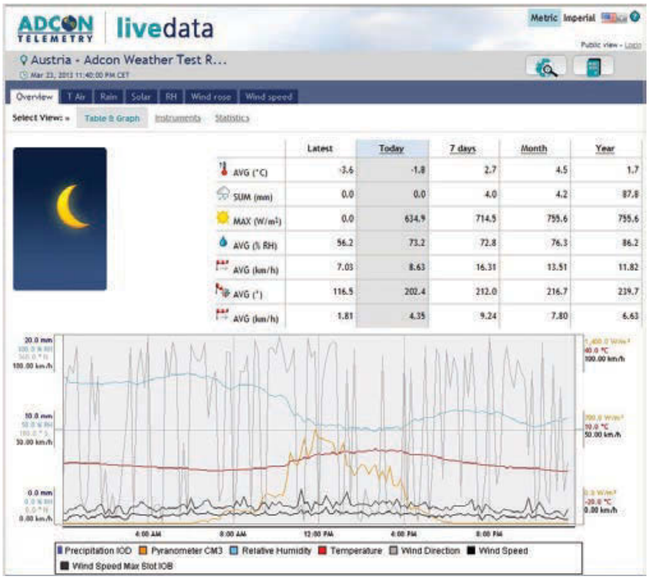
Air temperature, relative humidity (RH), wind speed and radiation data collected from an OTT weather station:

$e_a = RH \cdot e_{sa}/100\%$

The automatic weather station consists of a 2m mast to measure wind, temperature, humidity and global radiation, with a solar power package and a datalogger with remote



Accessible data should help farmers and horticulturalists improve irrigation



Evapotranspiration data can be displayed in 'annual view' format

transmission unit. In addition, a precipitation gauge is equipped with a windshield to improve catching efficiency at low precipitation rates and to reduce the effect of wind.

Maintenance issues

In operational precipitation networks, there is a direct relationship between the uncertainty of measurements and maintenance issues: relatively low levels of maintenance work lead to higher uncertainty in measured data. Scheduled maintenance on precipitation networks can result in data availability as low as 68%, whereas immediate reactive maintenance work can improve data availability to 85%. However, this means that 15% of the precipitation data would have to be interpolated from neighboring sites and maintenance costs would be relatively high.

Frequent tipping bucket raingauge (TBR) maintenance is needed due to environmental deposits such as leaves, dust, bird excrement and small animals penetrating the mechanism and/or blocking the funnel. As a result, TBRs typically require an onerous four-week maintenance schedule.

With low power consumption and a very low maintenance requirement, the OTT Pluvio² precipitation monitor addresses the problems associated with more traditional monitors. The addition of Pluvio² to a weather station with sensors for wind, temperature, humidity, global radiation and barometric pressure substantially lowers maintenance costs and improves the suitability of the station for remote monitoring applications.

Compact weather sensor system

The system consists of a Lufft WS501 meteorological sensor suite measuring wind direction and speed, air temperature and relative humidity, barometric pressure (optional), global radiation and precipitation, connected to an Adcon A753 datalogger with integrated GPRS communication, a base station A850 Telemetry Gateway (which can manage from one to 500 stations) and the software package addVANTAGE Pro 6.3, a data visualization, processing and distribution platform.

This station is designed to WMO guidelines with a 2m tripod mast and can be operated in a variety of modes. If external power (by battery or mains power supply) is available, the WS501 unit can be freely configured to read windspeed up to 10 times per second, delivering WMO-compliant wind gust and average readings. All other sensors would normally be read once per minute and the results aggregated into 10-minute averages.

If no external power is available, and the whole system is being powered by the internal battery of the Adcon remote telemetry unit (RTU), which in turn is charged by a small solar panel in DIN A5 format, the Lufft WS501 will read all parameters once per minute and aggregate these readings over a 10-minute interval.

These 10-minute aggregates, as stored by the Adcon RTU, are automatically transmitted to the A850 base station at user-definable intervals, for example once every 10 minutes or once per hour or once every four hours. The transmission interval is usually determined according to the availability of power.

Data stored in the A850 is handled by the addVANTAGE Pro 6.3 software. This fully integrated, browser-based software package contains a variety of processing extensions, one of which calculates evapotranspiration according to the modified Penman-Monteith equation as described in the FAO-56 Irrigation Paper. A further extension is available to convert these figures through a wide range of crop tables into crop-specific evapotranspiration.

The results of the computation can be displayed in tabular and graphical format, and can be accessed by web browser via a PC or through Livedata, a software module designed for smartphones. This module offers a wide variety of display options, ranging from a 24-hour to an annual view – as shown in the screenshots above.

Conclusion

In the past, real-time calculation of evapotranspiration has been limited by power, telecoms availability, a high maintenance requirement – or a combination of these. However, by combining Adcon communications and data management with computation in an automatic weather station complete with a low-maintenance OTT Pluvio² raingauge, farmers and horticulturalists will be able to make substantial improvements to the efficiency with which they manage irrigation water.

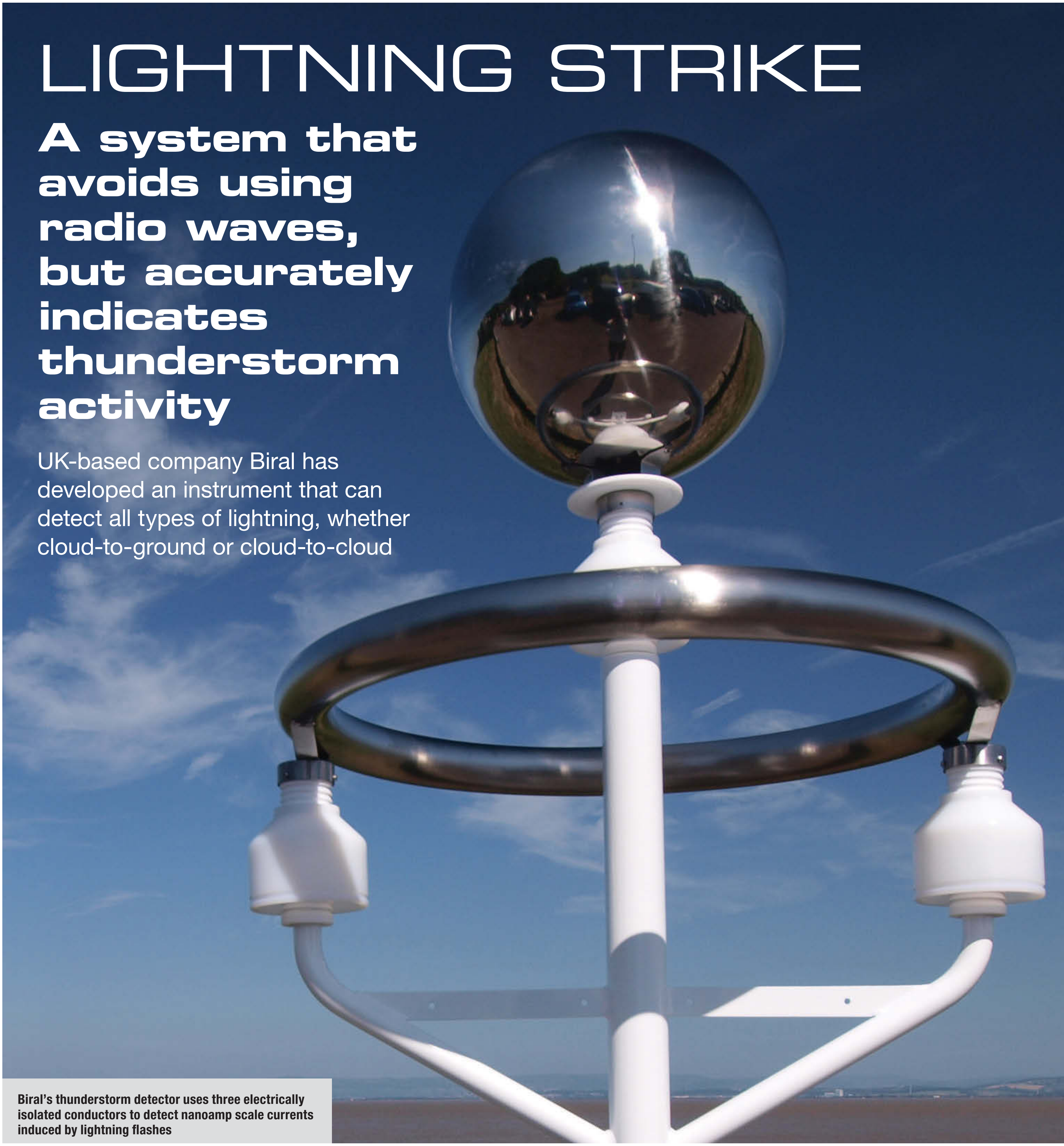
Kurt Nemeth is BDM for Meteorology at OTT Hydromet GmbH

by Alec Bennett

LIGHTNING STRIKE

A system that avoids using radio waves, but accurately indicates thunderstorm activity

UK-based company Biral has developed an instrument that can detect all types of lightning, whether cloud-to-ground or cloud-to-cloud



Biral's thunderstorm detector uses three electrically isolated conductors to detect nanoamp scale currents induced by lightning flashes

"One of the major advantages of such a system is that all types of lightning can be detected – both cloud-to-ground and cloud-to-cloud – which is not always the case for detectors using radio frequency methods"

Thunderstorms pose a major risk to human activity and infrastructure, with hazardous conditions ranging from floods to hail, tornadoes and lightning. The best indicator of thunderstorm activity is the presence of lightning, which fortunately produces a powerful, broad spectrum of electromagnetic signals revealing its presence thousands of kilometers away.

Radio waves from lightning are modified during their journey from the storm and while characteristics such as signal amplitude reduce with distance, such signal changes are not usually sufficiently robust to allow accurate ranging to the storm. Lightning location methods therefore either require signals received by multiple sensors arranged as a large network, or if only a single site is available, a receiver and complex processing algorithms analyzing various waveform characteristics to determine lightning range and in some cases direction as well. Unfortunately, lightning is not the only source of radio signals, so additional processing or sensors must be incorporated to separate radio noise from genuine lightning signals.

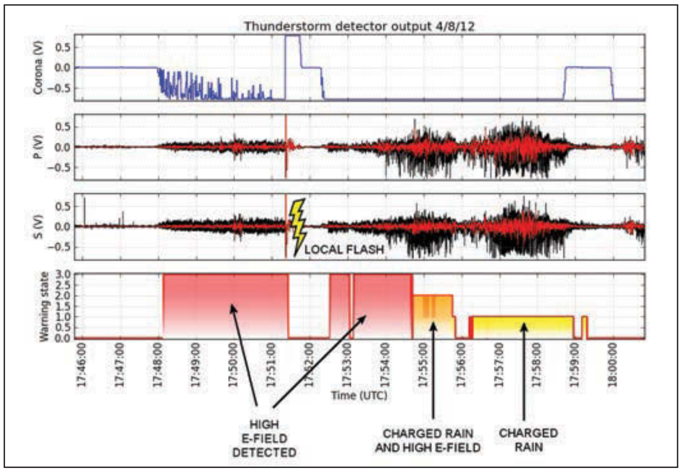
In addition to being a source of radio frequency signals, lightning also produces changes in the atmospheric electric field. Such changes are much slower than those from radio waves, with the frequency of lightning-generated atmospheric electric field changes being approximately 1-20Hz and lasting about 0.2 seconds on average. It was these quasi-electrostatic signals that were first used to study lightning before the introduction of good-quality radio receivers, and are still used in modern thunderstorm research, such as for measuring the total charge neutralized during a lightning flash.

With an increasingly crowded radio communication spectrum and a diverse variety of man-made radio noise sources, from 50/60Hz electric power 'hum' through to gigahertz frequency microwave transmissions, lightning detection and ranging methods that avoid radio waves altogether are appealing. One such sensor has been developed by Biral, exploiting the small currents induced on a conductor exposed to the quasi-electrostatic changes from lightning. The amplitude of these quasi-electrostatic signals is more strongly dependent on distance than is the case for radio frequency emissions, so they are well-suited to local, 100km or so, lightning detection. Such antennas have been used to study lightning for more than 100 years, but the unique feature of the Biral instrument is the use of two or more co-located antennas of different geometry. The outputs of these multiple antennas at a single site are used to effectively separate small and nearby electric field changes from sources such as raindrops or even birds flying overhead from the powerful but distant lightning flash. One of the major advantages of such a system is that all types of lightning can be detected – both cloud-to-ground and cloud-to-cloud – which is not always the case for detectors using radio frequency methods.

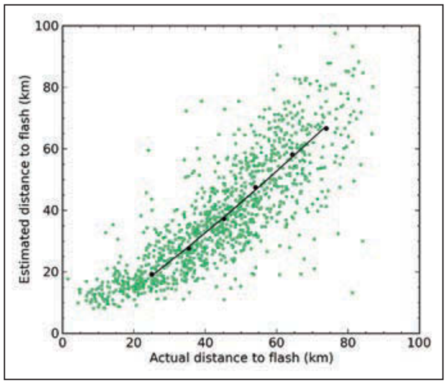
Prototype detectors

Two prototype detectors were deployed in southern England in May 2012 and have since recorded nearly 10,000 lightning flashes at distances up to 120km away. The technique assumes a typical charge neutralized by a lightning flash, with distance estimation based on the total change of the electric field produced by the flash. This change is proportional to the inverse cube of distance so is the dominant factor for flashes within 100km of the detector, despite the natural variability of the unknown lightning charge moment. In addition to determining the range of lightning flashes, the detector also exploits signals from nearby electrical charges from falling precipitation and corona discharge under strong atmospheric electric fields. Given that highly charged precipitation and strong local electric fields are both signs of deep convective cloud overhead, detection of these additional signs of disturbed weather are used to provide warning of possible local thunderstorm formation, even before the first lightning flash is detected.

> "Results from the comparison were very encouraging, with a strong correlation between lightning flash distances estimated by the single-site quasi-electrostatic method and the radio frequency network"



Warnings of strong electric field and electrically charged precipitation provide warning of local thunderstorm activity. The top plot shows corona discharge current (proportional to the atmospheric electric field), the middle two plots are current induced by the detector's two antennas, and the bottom plot shows occurrence of charged rainfall and strong electric field



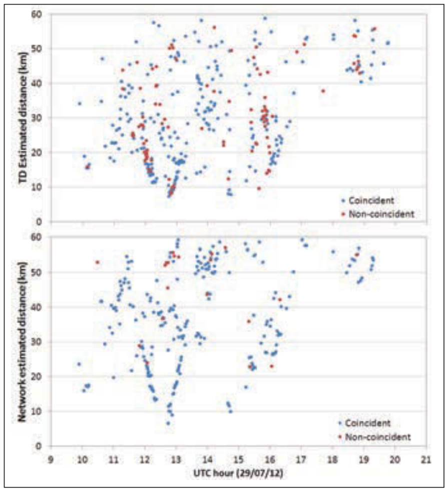
Comparison between distances to lightning flashes estimated by the Biral thunderstorm detector compared with that from a high-performance VLF/LF lightning location network, of suitable location accuracy to be considered the 'actual' distance. Green dots represent individual flashes and the larger black dots are median values, in 10km bins

The performance of the prototype thunderstorm detector was assessed by comparing it with data from storms in the summer of 2012 located by a high-performance lightning location network operating in the VLF/LF radio frequency bands. The network has demonstrated its ability to detect both cloud-to-cloud and cloud-to-ground flashes at sub-kilometer accuracies, so is used as the 'ground truth' of lightning activity around the prototype detectors.

Results from the comparison were very encouraging, with a strong correlation between lightning flash distances estimated by the single-site quasi-electrostatic method and the radio frequency network. Even this proof-of-concept detector managed an RMS ranging error of 5km between ranges of 0-20km and 9km from 20-60km, putting it within the strict limits for lightning detectors as defined by the US Federal Aviation Administration (FAA). As for detection efficiency, the prototype instruments detected all the flashes identified by the high-performance network within 20km of the site and 90% from 20-60km. In addition, on one day the prototype sensor detected 64% more flashes within 20km of the site and 35% more at the 20-60km range compared with the network, which produced 241 network-detected flashes within 60km. The signal characteristics and range of these additional flashes was consistent with storm locations already identified by the network, so were considered genuine additions to the total lightning activity detection. The reason these flashes were not detected by the network was likely to have been due to them having a low peak current (e.g. weak cloud-to-cloud flashes) and therefore producing insufficient VLF/LF radiation for network location, but producing a sufficiently large charge neutralization to be picked up by the quasi-electrostatic method.

The promising results and reliability of the prototype thunderstorm detectors were used to design a commercial product, which builds on the quasi-electrostatic field change technique for lightning ranging and overhead thunderstorm initiation alert. For situations requiring thunderstorm direction as well as distance from the site, the company is also developing an additional module based on the more traditional radio frequency magnetic direction finding method. Since this radio frequency dependent module does not need to discriminate between lightning and other sources of radio noise (this is done by the quasi-electrostatic antennas), the problems of false alarms from radio interference are mitigated.

Alec Bennett is the senior scientist for meteorological products at Biral



Comparison between estimated distances of flashes with time from the Biral thunderstorm detector (top) and a high-performance lightning location network (bottom). Blue dots represent flashes detected by both methods, with red being flashes detected only by the method represented. Flashes produced by multiple thunderstorm cells passing during a single day in July 2012

by Bob Moran and Paul Heppner

ON THE MOVE

Mobile platforms' role in high-density observations and road hazard detection

Weather Telematics and Global Science & Technology have jointly created a platform that processes meteorological and environmental data from mobile platforms

Meteorological observations that are high density (time and location) can indicate threat areas (icing, for example) in between fixed-site locations, and in many ways detect weather and environmental conditions that would otherwise go undetected.

Mobile platforms provide data attributes at a 10-second observation frequency. When traveling at a highway speed of 100km/h, mobile platforms record and transmit observations every 275m (900ft) in real time. The target server or customer receives these observations within 5-10 minutes of when they are taken.

The following attributes are part of a mobile platform observation: air temperature; pavement temperature; relative humidity; ambient light; precipitation; barometric pressure; and ozone.

The vehicle's position (latitude, longitude), elevation and speed data are also part of the observation. Derived parameters are then calculated – these include dewpoint, sea-level pressure, wind speed and direction, while lightning detection will be added in its next configuration.

The weather-sensing equipment is attached to the mobile platform (below left) and hooked into the vehicle's telemetry. There is no user intervention; the operation of the equipment is automatic and the cost is inexpensive, particularly when compared with the cost of automated weather stations. On a cost-value basis, mobile platforms provide tremendous value for the geographical area covered and the number of observations taken.

Mobile observations

On any given day, a mobile platform will typically take 2,500 observations per vehicle, which means that the typical vehicle covers approximately 500km of geography each day taking observations.

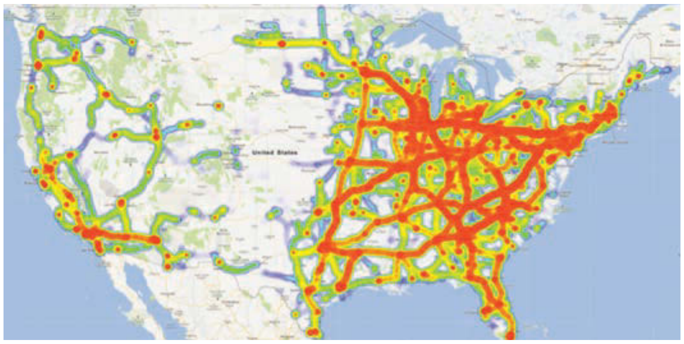
The network has a national footprint with Con-way Freight. The Figure below right shows the general geography covered by mobile platforms. There is coverage in all states of the Continental United States (CONUS), with a greater density in the eastern half of the country. An interesting statistic is that the current mobile fleet delivers more observations in a single day than the entire fixed RWIS network of 2,026 stations delivers in one week.

Mobile platform data is needed in the National Mesonet in order for the National Oceanic and Atmospheric Administration (NOAA) to meet its Weather Ready Nation objectives. The Mobile Platform Environmental Data (MoPED) system, created by GST, provides the Meteorological Assimilation Data Ingest System (MADIS) with more than two million mobile platform environmental observations per day from the Con-way fleet, via Weather Telematics.

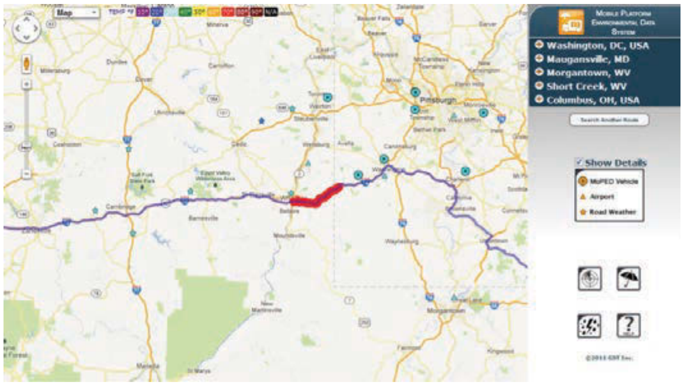
Mobile platforms are cited as viable and important new sources of data for 'filling in the gaps', as described in *From the Ground Up* and *Where the Weather Meets the Road*, both publications produced by the National Research Council.

Furthermore, in the Weather Ready Nation roadmap, NOAA states that "agile observational systems, such as mobile and targeted observing capabilities" are needed "to fill gaps that do not require persistent surveillance and provide critical high-resolution information to forecasters and across the weather enterprise". High-density

Weather instrumentation mounted on vehicle cab



Density map of the USA showing 31 days of MoPED observations during January 2013



Mobile platform identifying the potential icing hazard along a highway segment

"Observing techniques and capabilities can no longer be developed in isolation, but must operate as system within a system"

observations, which include mobile, are part of this solution because "observations are critical to achieving situational knowledge and enabling improved computer-generated analysis and predictive guidance. Observing techniques and capabilities can no longer be developed in isolation, but must operate as system within a system as part of the greater weather enterprise. Improving the precision and accuracy of neighborhood-scale forecasts requires observation and analysis of the lower atmosphere".

As noted in the roadmap: "Every sensor has strengths and weaknesses. For example, a satellite sensor's effectiveness is diminished by cloud cover, resulting in degraded measurements in the lower atmosphere. However, the same sensor provides the best resolution and coverage of any observing capability available. Radar 'sees' through weather and provides the most comprehensive understanding of weather over a large area, but is limited by the Earth's curvature."

Weather Ready Nation roadmap

The Weather Ready Nation roadmap specifically calls for agile and mobile sources of data (highlighted in the passage above) to fill data gaps. When mobile platforms are traveling hundreds of kilometers daily taking weather observations, they are filling data gaps. When mobile platforms are covering neighborhood areas, they do so with precision that cannot be obtained by fixed stations that may be dozens of miles apart. And in many instances, mobile platforms resolve phenomena that are missed by the limitations of satellites and radar.

In the one example near Kalispell, Montana, the mobile platform is providing a unique perspective of conditions near a body of water, when compared with the closest airport that is 25 miles away. The air temperature is much cooler along the lake front, and the relative humidity is much greater. The mobile platform detected a 91% relative humidity, compared with 54% at the airport.

In the urban area, mobile platforms provide mesoscale and 'neighborhood level' observations. In the following example, several mobile platforms are operating in the suburbs of Hartford, Connecticut, which is serviced by Bradley International Airport (KBDL) to the north of the city. The mobile platforms in this example operated to the south of the city.

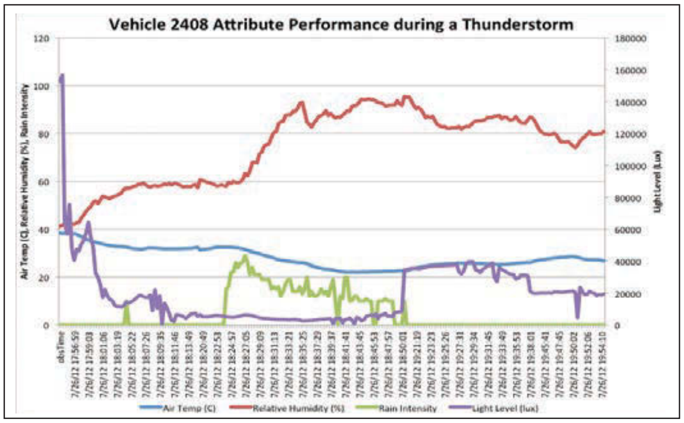
Mobile platforms also have a role with severe weather detection and forecasting. Mobile platforms with Conway have a significant footprint in New Tornado Alley (research by CoreLogic, in collaboration with the Storm Prediction Center), which can aid forecasters when looking at the pre-storm environment.

Although mobile platforms do not usually cross the path of tornados, mobile platforms may sample the pre-storm environment, prior to tornadic initiation, or in some cases be under the parent super-cell – and as such provide real-time data to NOAA about the storm's ambient surface environment. The example, the graph below left shows the transit of a mobile platform through a thunderstorm. The ambient environment prior to the encounter is sunny and hot, but as the mobile platform encounters the storm, there is a dramatic drop in light values, decrease in temperature, increase in relative humidity, and onset of precipitation.

Through these encounters, the mobile platform uncovers gust fronts and other storm phenomena, such as thermal boundaries. Such detection is very important because thermal boundaries are often the initiation sites for new convection.

The Winter months

During the winter half of the year, mobile platforms play a different role for threat detection. Instead of a focus on convection, the focus shifts to snow and ice hazards in the northern states. Mobile platforms are equipped with pavement temperature sensors. These infrared sensors provide detail of the pavement temperature, which in many cases will



Mobile platform transit through a thunderstorm directly affect the surface pavement condition, especially if the pavement is untreated. Mobile platforms are able to uncover hazard areas (see the red shaded area in the image, top right, on previous page), where pavement temperature less than 0°C, in conjunction with high relative humidity values and air temperatures less than 0°C, the formation of surface ice. Such graphical depictions can be made available to drivers before they set out on a journey, or updated 'in vehicle' through weather/traffic information subscription service. When so equipped, a mobile platform with meteorological information is capable of feeding back information to its driver of the potential hazard that exists, as indicated by the vehicle's meteorological instrumentation.

Mobile platforms detect cold pockets in valleys where freezing rain may fall or fog may form. The graphs of attributes help meteorologists and dispatchers to identify threatening phenomena or perhaps unexpected ambient conditions. The mobile platforms provide detail in areas between fixed sites where such phenomena might not be occurring.

Along some parts of the transit the mobile platform detects surface pavement temperature greater than 0°C, and along other areas it is much less than 0°C. The air temperature is slightly less than 0°C throughout the sequence. The surface conditions would be more treacherous where the pavement temperature is much less than 0°C after 14:06UTC in this example. Visualization tools, developed by the GST and Weather Telematics team, provide users the capability to mouse click on the time series graph at a point of interest (such as the pavement temperature much less than 0°C), at which moment a geographical map of the location where the event is occurring or was encountered will be displayed.

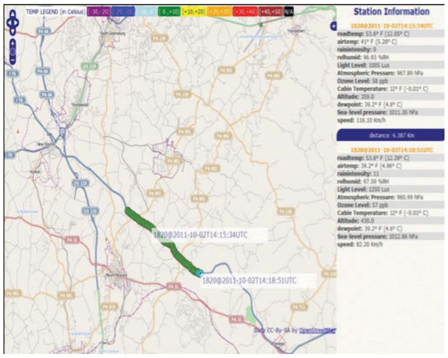
In addition to the ability to help distinguish and discriminate potential icing areas, mobile platforms also help resolve radar ambiguities. In the following example, the radar shows light precipitation, but in scattered patches near Latrobe, PA, in a mountainous area. The mobile platform is able to distinguish where the precipitation is reaching the ground or not. In this example shown in Figure 10, the precipitation near Latrobe, which is 5-10dBz signal return on radar, is indeed reaching the ground, as detected by the mobile platform. In many cases, the mobile platforms serve as "ground truth". In other instances, particularly where the radar is indeterminate or the location is far away from the radar site, the mobile platform actually resolves the phenomenon that the radar cannot.

The transit of a mobile platform mountainous terrain can often indicate near-surface freezing level, as the mobile platform is taking observations upon ascent or descent of terrain. The mobile platform is providing a ground-based AMDAR, so to speak.

Observations sent to NOAA

In summary, mobile platforms provide detailed observations to NOAA that help fill in data gaps, which is a critical element to mission success of the Weather Ready Nation objectives, and also of tremendous benefit to meteorologists, who are either monitoring meteorological conditions, or deciding if advisories or warnings need to be issued for specific areas. The hyper-local, fine detail observations provided by mobile platforms fill in the gaps, for certain. But to a greater extent, mobile platforms resolve ambiguity, provide ground truth, and identify hazard areas. Data assimilation of mobile platform observations into local-area models and Decision Support Systems may influence model outcomes and prognoses.

Mobile platform providing ground truth to radar data near Latrobe, Pennsylvania, USA



Beyond the benefit for agencies and organizations, there is a real source of observational data that can signal alerts to drivers in real time. In-cabin alerts and information to drivers will inform them of potentials outside, that otherwise could be unknown. Furthermore, with vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communications, those vehicles that uncover potential hazards then serve as information sources for those who might follow soon on the same segment of highway. A tremendous safety benefit can be realized by the acquisition of data from mobile platforms – for internal alerts (indicator to that driver) and for those in the vicinity or following on the same segment of highway. ■

Bob Moran, is from Weather Telematics and Paul Heppner is from Global Science & Technology, based in the USA

Index to advertisers

by Helge Tangen

A VIEW FROM THE TOP...

Helge Tangen, an expert in charge of weather prediction at the highest latitudes, discusses forecasting on the edge of northern civilization

Since 1866, the Norwegian Meteorological Institute (MET Norway) has struggled to improve weather forecasts for all seafarers in northern waters. Fishing, whale and seal hunting, and adventurous expeditions to Arctic areas, have been important for the Norwegian coastal population for centuries.

Today MET Norway is responsible for daily forecasting of the weather conditions in Arctic waters, from Greenland to Novaja Zemlja, and in principle to the North Pole, wherever open waters exist. The users are mainly fishing vessels, tourist ships, the oil and gas industry, and surveillance activity such as the coast guards.

Numerical weather forecasting has swiftly developed. But the real revolution has taken place in recent decades. After a validation campaign a few years ago, Met Norway admitted a weaker performance in Arctic waters than in more southern seas, such as the North Sea. This was taken seriously and in recent years resources have increased to improve Arctic forecasting. New models for ocean, sea ice and atmosphere have been developed and implemented. Among the reasons for lower performance in the north is the lack of in-situ observations. For logical reasons, the lack of infrastructure and populated areas have made traditional surface observations impossible over large areas. But the number of polar orbiting satellites is now increasing, and assimilation techniques have developed to support numerical weather models.

Ocean-atmosphere interaction is very important for forecasting, and the changing sea ice conditions over the past few years have added to the major challenge of Arctic forecasting.

The Arctic challenge

The sea ice cover in the Arctic has larger seasonal variations than we are used to seeing; this leads to new requirements for accurate description of the conditions in order to feed the models on a daily basis. Again satellite measurements are a great help, enabling us to improve the ice charts that MET Norway is producing daily for the European Arctic.

What are the remaining challenges concerning weather forecasting in the Arctic? Well, as the weather models still have their weaknesses, the skills of meteorologists are important. The human observer in cooperation with computers is what we consider to be a recipe for best practice.

An example of this is ‘polar low’ forecasting – these small and intense cyclones can do a lot of harm where they hit. For the past 20 years there has been increasing activity on understanding and forecasting polar lows. Due to the mentioned sea ice changes, we have lately observed the first polar low developing north of Svalbard, above 80° north. Since even the latest weather models do not go as far as taking in phenomena at the highest latitudes, the contribution from an experienced forecaster is crucial to forecasting correctly.

Another phenomenon connected to the sea ice is wind jets at low levels close to the ice edge. Trawlers need to fish close to the ice, and tourist cruisers want to approach the same areas, so accurate wind prognosis is important for safety reasons. These narrow belts of strong winds at the ice edge are not well represented in the weather models either.

Weather forecasters increase their skills with experience obtained by verifying their own forecasts. As mentioned earlier, surface observations are sparse in the Arctic, and accurate verification is not easy. This means that learning from hits or the failures is not easy. Senior forecasters can help out to some extent by conveying their experience to younger colleagues. There is also the challenge of really understanding the weather and sea conditions in a remote place like the Arctic.

The polar future

How do we foresee the future in Arctic forecasting? A continuous development of numeric models, with higher spatial resolution and better assimilation of satellite data, will probably lead to a significant improvement in forecasting within a few years.

Interest from oil and gas explorers, and from shipping lines aiming to use new Arctic sea routes, will also put pressure on providers of weather, sea ice and ocean forecasts. This will lead to new improvement projects, probably financed partly by stakeholders that have an interest in safe conditions for operations in the far north. As an expert in weather and ocean forecasting in the Arctic, I find this a very exciting prospect. ∎

Helge Tangen is regional director with the forecasting division in northern Norway, Norwegian Meteorological Institute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